
IN HOC SIGNO VINCES
Berry of Tayfield

SUPPLEMENT

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ENCYCLOPAEDIA BRITANNICA.

SUPPLEMENT

TO THE

ENCYCLOPÆDIA BRITANNICA.

SUPPLEMENT

TO THE

FOURTH, FIFTH, AND SIXTH EDITIONS

OF THE

ENCYCLOPÆDIA BRITANNICA.

WITH PRELIMINARY DISSERTATIONS

ON THE

HISTORY OF THE SCIENCES.

Illustrated by Engravings.

VOLUME THIRD.

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ADVERTISEMENT

TO

THE THIRD VOLUME.

According to the arrangement announced in the *Advertisement* prefixed to this Work, the Second Part of Mr Stewart's Dissertation *on the Progress of Metaphysical, Ethical, and Political Philosophy*, ought to have appeared with the present Half-Volume. The Editor has been induced so far to depart from that arrangement, as, in the meantime, to substitute Mr Brande's Dissertation, which was originally intended to be given with the *Fifth* Volume; and to give the remaining Part of Mr Stewart's Dissertation with the First Half of the Fourth Volume. The Second Part of Professor Playfair's Dissertation *on the Progress of the Mathematical and Physical Sciences*, will accompany the First Half of the Fifth Volume. Directions will afterwards be given as to how the whole ought ultimately to be placed.

The Editor takes this opportunity to state, that the Work is likely to extend beyond Five Volumes, the number specified in the *Advertisement*. There are many of the Letters of the Alphabet under which the numberof Articles necessary to be given will be comparatively small; and the Editor has endeavoured, by numerous retrenchments from his original plan, so to model the whole, as to keep within the intended limits; but he sees reason to fear, that this object could not be accomplished, without such a mutilation of the plan as would be greatly prejudicial to the utility of the Work. He does not, therefore, anticipate any displeasure from now announcing, that it may probably extend to, but not beyond, *Six* Volumes.

Edinburgh, February 1818.

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DISSERTATION THIRD:

EXHIBITING A GENERAL VIEW

OF THE

PROGRESS OF CHEMICAL PHILOSOPHY,

FROM THE EARLY AGES TO THE END OF THE
EIGHTEENTH CENTURY.

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CITY OF LONDON.

DISSERTATION THIRD.

SECTION I.

GENERAL VIEW OF THE PROGRESS OF CHEMICAL SCIENCE, FROM THE EARLY AGES TO THE END OF THE SEVENTEENTH CENTURY.

The phenomena of the universe present a series of changes, of which the regularity and harmonious succession excite the surprise of superficial observers, and awaken the admiration and attention of the philosophic mind.

These changes are either accompanied by visible motion susceptible of measurement, and relate to the exterior forms and mechanical characters of bodies, or they depend upon the mutual agencies of the elementary principles of matter, upon its composition, upon its susceptibility of acquiring new properties by entering into new combinations.

The investigation of the former phenomena belongs to the mechanical philosopher; to trace the causes of the latter, and to discover the laws to which they are obedient, is the business of chemical science.[1]

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[1] *Definitions of Chemistry.*—"La Chymie est un art qui enseigne à separer les differentes substances qui se rencontrent dans un mixte." (L'Emery, *Cours de Chymie.*)

"Chemistry is that science which examines the constituent parts of bodies, with reference to their nature, proportions, and method of combination." (Bergman, *Essay on the Usefulness of Chemistry.*)

"Chemistry is the study of the effects of heat and mixture, with a view of discovering their general and subordinate laws, and of improving the useful arts." (Black, *Lectures.*)

"La Chimie est une science qui apprend à connaitre l'action intime et réciproque de tous les corps de la nature, les uns sur les autres. Par les mots *action intime*, et reciproque, cette science est distinguée de la

Chemistry, considered as a branch of scientific inquiry, is not of ancient date. [1] Founded upon principles deduced from experiment and observation, centuries were

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physique experimentale, qui ne considère que les propriétés extérieures des corps doués d'un volume, et d'une masse quon peut mesurer, tandis que la Chimie ne s'attache qu'aux propriétés intérieures, et n'agit que sur des molécules, dont le volum eet la masse ne peuvent pas être soumis aux mesures et aux caleuls." (Foureroy, *Systême des Connoissance Chimiques*, Vol. I. p. 4.)

" Die Chemie ist eine Wissenschaft die uns die wechselseitige wirkungen der einfaehern Stoffe in der Natur, die zusammensetzung der körper aus ihren und naeh ihren versehiedenen verhältnissen, und die Art und Weise kennen lehrt, sie zu trennen, oder sie wieder zu neuen Körperarten zu verbinden." (Gren. *Systematisches handbuch der Chemie*, p. 1. Halle, 1794.)

" Chemistry is that science which treats of those events or changes in natural bodies, whieh are not accompanied by sensible motions." (Thomson, *System of Chemistry*, fifth edition, p. 2.)

Most of the substances belonging to our globe are constantly undergoing alterations in sensible qualities, and one variety of matter beeomes, as it were, transmuted into another. Such ehanges, whether natural or artifical, whether slowly or rapidly performed, are ealled chemieal;—thus the gradual and almost imperceptible decay of the leaves and branches of a fallen tree exposed to the atmosphere, and the rapid combustion of wood in our fires, are both ehemieal operations.

" The object of ehemieal philosophy is to aseertain the causes of all phenomena of this kind, and to diseover the laws by whieh they are governed." (Davy, *Elements of Chemical Philosophy*, p. 1.)

In the edition of Johnson's *Dictionary*, now publishing by the Rev. H. J. Todd, the erroneous and antiquated definition of Boerhaave is very improperly retained. " An art whereby sensible bodies contained in vessels, or capable of being contained therein, are so ehanged by means of certain instruments, and prineipally fire, that their several powers and virtues are thereby diseovered, with a view to philosophy or medicine."

The derivation of the word Chemistry ean scarcely be said to have been ascertained. The most plausible guesses are the following: from χυω to melt, or χυμος juiee; from *kema*, an oriental word signifying *black*; from χιμης, the name of a person eminently skilled in the scienees; from *Chêmi*, the Coptic name of Egypt, where the art is supposed to have had its rise.

Aeeording to Bryant (*Ancient Mythol.*), it is derived from *chemia*, and that word from *Cham.*

The Rev. Mr Palmer, Professor of Arabie at Cambridge, has given the following etymology: " Al-chemy, or more properly Al kemy, the knowledge of the substance or composition of bodies, so named from the substantive (Kyamon), that is, the substanee or constitution of any thing; from the root (Kama). Golius. *Lexicon.*" (Thomson's *Chemistry*, 5th edit. p. 4. Note.)

Conversing upon this subjeet with Dr Thomas Young, he remarked, that the Egyptians probably neither knew nor cared much about the *composition* of bodies; and that the term Chemistry, as referring to the seeret art of transmutation, was probably derived from the Coptic root *hhems* or *chems*, signifying *obscure*, *dark*. The German word *geheim, secret*, he said, was perhaps of the same root.

" Hæe ars varia accepit nomina, nam omnium primò dicta fuit τεχνη ποιητικὴ, et antiquis illis temporibus per hane vocem significabant artem vilia metalla in aurum convertendi, et ejus artifices ποιηταὶ voeari Zozimus dicit. Veteres Ægyptios hane artem *Chimoet* vocasse Josephus Sealiger ibi ostendit, sed postea Græci hane artem χρυσοποιησιν dixerunt, Arabibus vero, *Alchemia*." (Boerhaave, *Institutiones Chemiæ*.)

[1] " Tout ee qu'on a dit de l'antique origine de la Chimie, sur les premiers hommes qui ont travaillé les metaux, taillé et poli les pierres dures, fondu les sables, dissous et crystallisé les sels, ne montre à un esprit exact et sévère qu'une vaine et ridicule pretension, semblable à cette par laquelle on voudrait reconnoître

consumed in their accumulation and systematic arrangement; but, as an art, chemistry is readily traced to periods of remote antiquity; for it is obvious that the chemical changes of matter must have been rendered subservient to the wants of mankind in the earliest ages of the world.

Metallurgy is among the most ancient of the arts, and Tubal Cain, the instructor of workers in iron and brass, has thence been called the inventor of chemistry. Others have preferred the claims of Noah, to whom the invention of wine has been attributed; but these, and other arts alluded to in Sacred Writ, such as dyeing, gilding, and embalming, which have been adduced as instances of chemical knowledge in the time of Moses, prove nothing more than that such processes were practised at that period, independent of each other, and quite unconnected by the slightest reference to general principles.[1]

It is probable that the early mythological systems of the Egyptians contained some allusions to the chemical changes of matter, and to them the first speculations on the art of transmutation have been attributed. Hermes, or Mercurius Trismegistus, the favourite minister of the Egyptian king Osiris, has been celebrated as the inventor of this art, and the first treatise upon it has been attributed to Zosymus, of Chemnis or Panopolis in Egypt. The inhabitants of Sydon and Tyre, those renowned seats of the commerce of the ancient world, seem to have been skilled in some chemical manufactures; they made glass and artificial gems, and excelled in dyeing purple.

Egypt maintained its superiority in arts until the invasion of Alexandria by the Saracens, when the clebrated library collected by the Ptolemies, with great diligence and at enormous expence, was burned by the orders of Caliph Omar.[2] The alchemical

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les élémens de la géométrie dans l'ouvrage grossier du sauvage qui use les fragmens du rocher, qui leur donne des formes à peu près régulières pour les rendre utiles à ses premiers besoins." (Fourcroy, *Discours Préliminaire.*)

[1] " Si l'on examine cependant avec courage et sans préjugé toutes les preuves qu'on a réunies pour etablir l'existence de la Chimie chez les Egyptiens, après avoir reporté son origine aux premiers âges du monde et aux prémiers travaux ou les hommes ont employé le feu comme agent, on reconnaît bientôt que tirées uniquement des products employés dans leurs constructions diverses, elles peuvent toutes annoncer des arts ou des procédés de fabrique plus on moins avancés, mais rien qui tienne à des notions générales tirées de ces arts, comparés rien qui depende d'une doctrine suivie, rien enfin qui puisse donner une idée d'une veritable science." (Fourcroy, *Disc. Prél.*)

[2] " Qui his scriptis parcendum esse negabat, quippe quæ inutilia essent, si eorum dogmata Alcorano congruerent, noxia vero, si ab illo dissentirent." (Bergman, *De primordiis Chemiæ.*)

works had been previously destroyed by Diocletian in the fourth century, lest the Egyptians should acquire by such means sufficient wealth to withstand the Roman power. On the present occasion, about seven hundred thousand volumes were seized, which we are told supplied six months' fuel for forty thousand baths, that contributed to the health and convenience of the populous capital of Egypt.

When philosophy declined in Egypt and in the East, Greece became the principal seat of learning and of the arts; but the systems of their early philosophers, of Thales [1] the founder of the Ionic sect, of Anaximander, and Anaximenes, breathe the sentiments of the Egyptian schools. By Thales water was considered as the source of all things, as the universal element. The opinions of Anaximander, in themselves unintelligibly obscure, received some elucidation from his successor Anaximenes; they regarded air and fire as the first rudiments of matter.

The result of the Macedonian war introduced Grecian philosophy into Italy, and the doctrines of Plato, [2] and Aristotle, and Theophrastus, prevailed in the school of Rome.

Among the early Roman philosophers, Lucretius [3] stands preeminent; but his opinions had been formed at Athens, in the Stoic school of Zeno, and he early imbibed the doctrines of Empedocles and Epicurus, which are expounded with superior genius and admirable ingenuity in his masterly poem on the *Nature of Things*.

The celebrated Natural History of the elder Pliny, written in the first century of the Christian era, contains an account of the rise and progress of the arts and sciences previous to that period, which, though not always accurate, often obscure, and sometimes unintelligible, abounds in instructive documents and interesting remarks. It is written, not in the elevated, refined, and elegant style of the Augustan age, but in the language of the laborious and liberal historian, frequently led by the extent of his inquiries to subjects which he is incompetent to manage, and upon which his opinions are incorrect, his conjectures vague, his assertions ill-founded.

The origin of many of the follies and mysteries of Alchemy may perhaps be referred with most propriety to the *New Platonists*, whose rise marked the declining age of learning towards the end of the third century of the Christian era. These philosophists, celebrated for their metaphysical disputes and superstitious notions, credited the existence of demons and spirits, with whom they claimed familiar intercourse. Ne-

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[1] 500 years B. C. [2] 340 years B. C. [3] 50 years B. C.

glecting useful knowledge, they exhausted their strength in verbal disputes, and in attempts to discover the secrets of the invisible world; thus gradually converting the study of philosophy into that of demonology and magic. " Several of these masters," says Gibbon," Ammonius, Plotinus, Amelius, and Porphyry, were men of profound thought and intense application: but, by mistaking the true object of philosophy, their labours contributed much less to improve than to corrupt the human understanding."

Porphyry died about the time of Diocletian's abdication. The life of his master, Plotinus, which he composed, gives a complete idea of the genius of the sect, and the manners of the Professors. This curious piece is inserted in Fabricius. (*Bibliotheca Græca*, Tom. IV.) When the cultivated part of Europe was overwhelmed by the barbarous nations, all records of arts and sciences possessed by the Greeks, and by their Roman successors, were swept away in the general destruction, and now the Arabians became the protectors of philosophy, and the promoters of its pursuits. To them, Chemistry, regarded as a distinct branch of experimental philosophy, owes its origin, and several circumstances co-operated to render its progress rapid, which are important in their relation to the subsequent advances of the science. Among these the mysteries of Alchemy, so well adapted to the genius of that age and people, are the most remarkable. Of this occult art, the two leading objects were the *transmutation* of common metals into gold and silver, and the discovery of the *universal medicine*, which, by the removal and prevention of disease, should confer immortality upon the possessors of the secret.

The origin of these chimerical notions has been variously accounted for. The idea of transmutation may plausibly be referred to the various processes to which natural bodies were submitted by the astrological experimentalists of the seventh and eighth centuries. Observing the change of properties in metallic ores by exposure to heat, and the production of malleable and useful metals from their brittle and useless compounds, it is not surprising that superficial observation and incorrect reasoning should lead to a belief in their production and transmutation; and such speculations, not without apparent foundation, holding out attraction to the ambitious, and hope to the needy, would soon excite notice and command followers. That this was the case, the records of those times amply testify.

The pursuit of the other object may be referred to the success attending the medical employment of many of the chemical preparations. Pharmacy was becoming enriched by the introduction of chemical compounds; and remedies for diseases, before deemed incurable, were occasionally discovered among the products of

the furnace. Hence, perhaps, the possibility of the existence of an universal remedy might occur to those under the infatuations of the black art.

The earliest of the true Alchemists, whose name has reached posterity, is Geber, [1] supposed to have been an Arabian prince of the seventh century. The works attributed to Geber, several of which have been published in Latin translations by Golius, and others in English by Russell, are numerous and curious. They abound in the cant and jargon of the hidden art. Some have asserted his pretensions to the possession of the universal medicine, for he speaks of curing disease. But this seems a mere metaphorical expression, relating to transmutation. "Bring me," says he, "the six lepers, that I may cleanse them;" by which he doubtless would imply the conversion of silver, mercury, copper, iron, tin, and lead, into gold,—there being only these seven metals known at that period. Dr Johnson supposes that the word *Gibberish*, anciently written *Geberish*, was originally applied to the language of Geber and his tribe.

The elder Mesue and Avicenna, [2] physicians of the ninth and tenth centuries, have given some account of the Chemistry of their age, but their works relate chiefly to medicine. Indeed, it is probable that the writings now extant in the name of the former are spurious.

The twelfth, thirteenth, and fourteenth centuries, abound in writers on the secrets of Alchemy; and the happy few to whom fate and metaphysical aid had granted the discovery of the great secret, assumed the title of *adepts*, a character which required to be sustained by superior feats of deception and duplicity.

About this period, several circumstances happily concurred, favourable to the diffusion of learning and the arts, which began again to dawn in Europe with promising splendour.

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[1] "Primus omnium Arabum post Græcos est *Geber*, cui dant titulum Arabis. Aliidicunt eum fuisse regem, unde *rex Geber Arabs*, dici solet; sed *Leo Africanus* qui Græcus fuit et multa descripsit ex antiquis Arabibus, dicit, Gebrum illum natione Græcus fuisse, sed derogasse suam religionem, et se dedisse Mahomedæ religioni Arabum, et vixisse septimo seculo." (Boerhaave.)

Geber was also a physician and astronomer. The following are the principal works on Chemistry which have been attributed to him: *De Alchemia,—De summâ perfectione Metallorum,—De Lapide Philosophico,—De inveniendi arte Auri et Argenti.* These, and some other works bearing his name, whether genuine or not, furnish good specimens of the early alchemical writings.

[2] Avicenna introduced several important drugs into the *Materia Medica;* and the art of making sugar has been enumerated among his discoveries, although, doubtless, of earlier date.

The extravagant expeditions of the Crusaders tended, in these respects, to the most extensive, beneficial, and permanent consequences. In their progress to Palestine, these ardent followers of the Cross traversed countries which, compared with their own, were cultivated, civilized, and refined. Their minds and manners were thus enlarged and improved, and new customs and institutions attracted their notice.

In Constantinople, then the largest and most magnificent of European cities, some traces of ancient elegance and refinement were still to be found, and many of the natural products and of the manufactures of the East were offered to their notice.[1]

We accordingly discover in these superstitious and enthusiastic expeditions the source of many improvements, which afterwards raised Europe to the highest rank among nations; which tended to dispel barbarism, to mitigate the fury of war, and to extend commerce; and which ultimately led to the cultivation of the useful and fine arts, and to the diffusion and exaltation of science.

Another event occurred about this period, which miraculously facilitated the acquisition and propagation of learning, namely, the invention of printing, which, as it were by superhuman mediation, advanced so rapidly to perfection, that the finest specimens of typography are to be found among the early efforts of the art. It was introduced into England by the Earl of Rivers, in the reign of Edward IV.[2]

Of the earlier writers on Chemistry, no one is more deserving notice than the celebrated Roger Bacon, a native of Somersetshire, who flourished in the thirteenth century. His writings, though troubled and polluted by the reigning absurdities of Alchemy, contain many curious facts and judicious observations. To him the discovery of gunpowder has, with all appearance of justice, been attributed.[3] "From saltpetre and other ingredients," he says, "we are able to form a fire which will burn to any distance." And again, alluding to its effects, "a small portion of matter, about

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[1] "The first and most obvious progress was in trade and manufactures,—in the arts, which are strongly prompted by the thirst of wealth, the calls of necessity, and the gratification of the sense or vanity. Among the crowd of unthinking fanatics, a captive or a pilgrim might sometimes observe the superior refinement of Cairo and Constantinople. The first importer of windmills was the benefactor of nations; and if such blessings are enjoyed without any grateful remembrance, history has condescended to notice the more apparent luxuries of silk and sugar, which were transported into Italy from Greece and Egypt." (Gibbon, *General consequences of the Crusades*, Vol. XI. p. 289. Edit. 1813.)

[2] Hume. Edward V.

[3] Watson's *Chemical Essays*, Vol. I.

It has been by some imagined, that Roger Bacon invented the air-pump; but the idea rests upon very doubtful expressions. (Boerhaave, *Instit. Prolegom.*)

the size of the thumb, *properly disposed*, will make a tremendous sound and corruscation, by which cities and armies might be destroyed." And again, in the same work, is a passage which, though somewhat enigmatical, is supposed to divulge the secret of this preparation. "Sed tamen salis petræ, *luru mone cap urbre*, et sulphuris, et sic facies tonitrum si scias artificium." The anagram is convertible into *carbonum pulvere*. Such are the claims of Roger Bacon to a discovery which soon changed the whole art of war.

The works of Bacon most deserving perusal are the *Opus Majus*, edited by Dr Jebb in 1733; and his *Epistola de secretis Operibus Artis et Naturæ, et de nullitate Magiæ*. Paris, 1532. The former, addressed to Pope Clement IV., breathes sentiments which would do honour to the most refined periods of science, and in which many of the advantages likely to be derived from that mode of investigation insisted upon by his great successor Chancellor Bacon, are anticipated.

Raymond Lully, Arnold of Villanova,[1] John de Rupescissa, and Isaac and John of Holland,[2] were Alchemists of the thirteenth, fourteenth, and early part of the fifteenth century. Their writings are extremely numerous; and they each treat of the philosopher's stone, and other secrets of the occult science.

Basil Valentine of Erfurt, who wrote towards the end of the fifteenth century, is deserving of more attention, and ranks among the first who introduced metallic preparations into medicine. In his *Currus Triumphalis Antimonii*,[3] after setting forth the chemical preparations of that metal, he enumerates their medicinal effects. According to the notions of the age, he boasts of supernatural assistance; and his work furnishes a good specimen of the controversial disputes between the chemical physicians and

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[1] Raymond Lully was born in Majorca in 1236, and Villanova in Provence in 1235. Their writings are as obscure as they are voluminous.

[2] "Sequuntur nunc Johannes et Isaacus Hollandus, pater et filius, qui diffusissimo sermone et magne eloquentiâ scripserunt, et si unum vel alterum arcanum exceperis pulcherrima experimenta fecerunt de sanguine et urinâ humanâ, quæ Helmontius postea et Boylæus pro recentioribus inventis habuerunt." (Boerhaave.)

[3] It is probable that the word Antimony was first used by Basil Valentine. Tradition relates, that having thrown some of it to the hogs, after it had purged them heartily, they immediately fattened; and, therefore, he imagined, that his fellow monks would be the better for a like dose, they having become lean by fasting and mortification. The experiment, however, failed, and they died; whence the medicine was called *Anti-moine*.

He published several other works besides the *Currus Triumphalis Antimonii*. See Chalmers's *Biograph. Dict.*

those of the school of Galen,—the former being attached to active remedies, the latter to more simple and inert medicines. The *Chariot of Antimony* opens with the most pious exhortations to prayer and contemplation, to charity and benevolence. But the author, soon forgetting himself, breaks out in the following strain of virulent invective. "Ye wretched and pitiful medicasters, who, full of deceit, breathe out I know not what Thrasonick brags;—infamous men, more mad than Bacchanalian fools! who will neither learn, nor dirty your hands with coals! you titular doctors, who write long scrolls of receipts; you apothecaries, who with your decoctions fill pots no less than those in princes' courts, in which meat is boiled for the sustenance of some hundreds of men; you, I say, who have hitherto been blind, suffer a collyrium to be poured into your eyes, and permit me to anoint them with balsam, that this ignorance may fall from your sight, and that you may behold truth as in a clear glass. But," says Basil Valentine, after a long exhortation in this strain, "I will put an end to my discourse, lest my tears, which I can scarcely prevent continually falling from my eyes, should blot my writing, and, whilst I deplore the blindness of the world, blemish the lamentation which I would publish to all men."

Such is the trash in which these authors abound, and in which curious facts and ingenious speculations are often enveloped.

Basil Valentine was succeeded by the more celebrated Paracelsus, a native of a village near Zurich in Switzerland. [1] In this remarkable person, all the follies and extravagance of the Alchemists were united;—he pretended to the discovery of the grand secret of the universal remedy; and his writings, which are very numerous, overflow with the whims and oddities of the sect; his zeal was more directed to the acquisition of popularity than to the advancement of science; his enthusiasm was ever misemployed; and he sought the elevation of his own character in the abuse and depretiation of his predecessors and contemporaries. He terminated a life, stained with every vice, and deficient in every virtue, in the year 1541, at an obscure inn at Saltzbourg, in Bavaria.

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[1] He assumed the formidable title of Philippus Aureolus Theophrastus Bombastus Paracelsus ab Hohenheim.

"Hunc virum," says Boerhaave, "alii coluerunt pro Deo, imo locutus sum cum hominibus qui credunt eum non esse mortuum, sed vivum sedere in sepulchro pertæsum peccatorum et malorum hominum." The following is an illustrative anecdote of his impudence: "Cum adscenderet Cathedram physico medicam, sumsit vas æneum cum igne, immisit sulphur et nitrum, et simul Galenum, Avicennam, et Arabes conjecit in ignem, dicens, sic vos ardeditis in gehennâ."

In the history of medicine, Paracelsus deserves more honourable mention; for he enriched the *Materia Medica* with many powerful remedies, derived from the mineral world, among which several preparations of mercury deserve especial notice; nor was he unacquainted with the virtues of opium, and other powerful drugs of vegetable origin. These he administered with a daring but often successful hand, and gained such celebrity, that, in 1527, he was promoted by the magistracy of Basle to the office of Professor of Physic. In this he expounded his own doctrines, asserting that that which was denied him from above had been granted by the infernal deities; and that to them he was indebted for those great secrets of physic and philosophy which he should divulge for the advantage and salvation of his hearers. Paracelsus, however, soon became weary of his situation, and terminated his professorial career, which was ill suited to his genius and inclinations, in the year 1528; he left Basle, nd his subsequent life was one disgusting scene of dissolute irregularity.

The last person whose name deserves to remain upon the chemical records of the sixteenth century is Van Helmont of Brussels, born in 1577,[1] who, at an early age, made considerable progress in philosophical studies. As a physician, he adopted the doctrines of the chemical school, and rejected those of Aristotle and Galen; he effected cures so numerous and surprising, that he was accused by the inquisition of employing supernatural means, which induced him to retire into Holland. The writings of Van Helmont are chiefly upon medical subjects; those connected with chemistry contain some curious speculations respecting aeriform fluids, which he calls *gases*, a term now in common use. He also speaks of a subtile invisible agent, called *Blas*, which, he says, is an etherial emanation from the heavenly bodies. "Winds are air agitated by the *Blas* of the stars."[2]

The doctrine of the Four Elements, as established by the ancient philosophers, underwent several alterations in the hands of the chemists of the sixteenth century. The former regarded Earth, Water, Air, and Fire, as the universal rudiments of all matter, and assigned to each its particular station in the universe. Earth tended towards the centre, water to the surface of the globe; air occupied a middle station between water and fire, which last was considered as the most rare, subtile, and active of all things;

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[1] The year 1558, given in Moreri, *Dictionnaire Hist.* is obviously incorrect, "Anno 1594, qui erat mihi decimus septimus," &c. (Van Helmont, *opera omnia*, 1707. *Studia Authoris.*)

[2] "Nescivit inquam schola Galenica hactenus differentiam inter gas ventosum, quod mere aer est, id est ventus per siderum blas commotus, gas pingue, gas siccum, quod sublimatum dicitur, gas fuliginosum sive endemicum, et gas silvestre sive incoercibile, quod in corpus non cogi potest visibile." (*Oper. om.* p. 399.)

it was supposed to constitute the heavenly bodies, and to confer life and action upon the other principles, to various combinations of which the different productions of nature were referred.

Basil Valentine, Paracelsus, and Van Helmont, speak of Salt, Sulphur, and Mercury, as the elementary principles of bodies; but the passages in their works referring to this hypothesis, are too dark and absurd to merit quotation; it was, however, adopted by several of their contemporaries and successors.

During the sixteenth century, some progress was made in the elucidation of the chemical arts, especially of Metallurgy, upon which subject the works of Agricola,[1] and of Lazarus Erckern, merit particular notice. The former has detailed, at considerable length, the various operations employed in mining, and his descriptions are at once correct and elegant; but his attempts at theory are deeply tinctured with the prevailing follies of the age. Agricola, who died at Chemnitz in 1555, was succeeded by Erckern, superintendent-general of the German mines; "he is an experienced, candid, and honest writer, relates nothing but what he had himself seen, without a word of theory or reasoning, and every where speaks as if he were sitting before the furnace and relating what passed."[2]

After wading through the thick fog of alchemical speculation, which envelopes the writers of this period, it is a relief to meet with one whose details are thus intelligible, and who adheres to matter of fact.

The periods we have now considered teemed with searchers for the philosopher's stone,—the elixir of life,—and the universal medicine. Of these such have hitherto only been noticed as conduced, by their experiments and discoveries, to the progress of chemical science.

The records of the fifteenth and sixteenth centuries present a motley group of these adventurers solely devoted to the occult art of transmutation. Some were open impostors; others deluded believers; but their respective histories are, in general, so similar,

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[1] The mineralogical works of Agricola display very minute information upon the most important parts of his subject. They are, 1. *De ortu et causis subterraneorum*. 2. *De natura eorum quæ effluunt ex terrâ*. 3. *De natura Fossilium*. 5. *De medicatis fontibus*. 6. *De subterraneis animantibus*. 7. *De veteribus et novis metallis*. 8. *De re metallica*. This last has passed through several editions, and is an excellent compendium of what was then known upon the theory and practice of the miners art, and of the working of metals.

[2] " Liber ejus (Lazer. Erckern), in folio, est editus linguâ Teutonicâ, pollicem crassus et iterum recusus est in Germana, in 4to. Est auctor in hac parte optimus." (Boerhaave.)

that an account of one will suffice:[1] Bernard Trevisan, who was born at Paris early in the fifteenth century, and who suffered severely under this intellectual epidemic, may be cited for the purpose. He commenced his career with the unsuccessful repetition of certain processes of transmutation described by Rhazes, in which he expended eight hundred crowns. The perusal of Geber's treatise on the perfection of the metals rekindled his hopes, and, after wasting two thousand crowns upon apparatus and materials, this experiment proved as fruitless as the former. The writings of Ruspescissa, Archelaus, and Sacrobosca, shortly afterwards engaged his notice; and, to ensure success, he associated himself with a monk, and performed a variety of silly but laborious experiments, at the expence of more than a thousand crowns. He submitted the same portion of spirit of wine to three hundred distillations, and was engaged during a period of twelve years, in a series of fruitless and unmeaning operations upon alum, common salt, and copperas. At length he quitted his native country for Italy; thence he proceeded to Spain and Turkey, in search of the adepts of the art, from whom he hoped to acquire the secret, and reimburse himself. Thus having squandered the scanty remains of his broken fortune, and reduced nearly to beggary, he retired to the isle of Rhodes, where he entered the service of Arnold of Villa Nova, from whom he states that he obtained that which he had so long searched for. So true is that definition of Alchemy, which describes it as an art without principle, which begins in falsehood, proceeds in labour, and ends in beggary.

Entering upon the seventeenth century, the historian of Experimental Science must ever pause to pay a tribute of gratitude and respect to the celebrated Francis Bacon; a man whose faults as a statesman have been eclipsed to the eyes of posterity, by the brilliancy and excellence of his philosophical character.

It may commonly be observed, that those who are gifted by nature with superior genius or uncommon capacity,—who are destined to reach the meridian of science,

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[1] Among the English alchemists, we may enumerate George Ripley, who, in 1471, wrote the *Compound of Alchemie*, dedicated to Edward IV.; and the celebrated Elias Ashmole, who called himself *Mercuriophilus Anglicus*, and who published and edited many treatises on alchemy. He founded the Ashmolean Museum at Oxford in 1679. The reader who may wish to amuse himself with the nonsense of our own alchemists, is referred to the *Theatrum Chemicum Britannicum, containing severall poeticall pieces of our famous English philosophers who have written the Hermetiyue mysteries in their owne antient language. By* Elias Ashmole, Esq. *Qui est Mercuriophilus Anglicus*, and to the celebrated alchemical work *Philalethes*.

The following act of parliament, which Lord Coke calls the shortest he ever met with, was passed in the fifth year of Henry IV.: "None from henceforth shall use to multiply gold or silver, or use the craft of multiplications, and if any the same do, he shall incur the pain of felony." (Watson's *Chemical Essays*.)

or to attain exalted stations in the learned professions, have exhibited early symptoms of future greatness: either indefatigable industry, or extraordinary sagacity, or ardent enthusiasm, have marked their entrance into the affairs of life. At the age of sixteen, Bacon was distinguished at Cambridge; and, very shortly afterwards, struck with the frivolous subtilty of the tenets of Aristotle, he appears to have turned his mind into that channel which led on to future eminence. The solid foundation of his scientific character is the *Instauration of the Sciences*. It opens with a general and philosophical survey of the subject; whence he proceeds to infer the futility of the ancient philosophical systems, and to point out Induction, from sober and severe experiments, as the only road to truth. Pursue this, he says, and we shall obtain new powers over nature; we shall perform works as much greater than were supposed practicable by natural magic, as the real actions of a Cæsar surpassed the fictitious ones of a hero of romance.

Speculative philosophy he likens to the lark, who brings no returns from his elevated flights; experimental philosophy to the falcon, who soars as high, and returns the possessor of his prey.

Illustrations of the new method of philosophizing, and the mode of arranging results, conclude this admirable and unrivalled performance.

To do justice to this work, we must, for a moment, forget the present healthy and vigorous constitution of science, and view it deformed and sickly in the reign of Elizabeth. We shall then not be surprised at the irrelative observations and credulous details which occasionally blemish this masterly production of the human mind.

But the history of Lord Bacon furnishes other materials for reflection. Upon the accession of James I., he became successively possessed of the highest honours of the law, and acquired great celebrity as a public speaker and a man of business; yet, amidst the harassing duties of his laborious avocations, he still found time to cultivate and adorn the paths of science, the pursuit of which furnished employment for his scanty leisure and relaxation in his professional toils; and, when ultimately disgraced, "his genius, yet unbroken, supported itself amidst involved circumstances and a depressed spirit, and shone out in literary productions." Nor should the munificence of his royal master remain unmentioned, who, after remitting his fine, and releasing him from his prison in the Tower, conferred upon him a large pension, and used every expedient to alleviate the burden of his age, and to blunt the poignancy of his sufferings.

After the death of Lord Bacon, which happened in April 1626, in the 66th year of his age, the records of science begin to assume a brighter aspect; and we discern true knowledge emerging from the dungeons of scholastic controversy, and shaking off the shackles of polemical learning.

The philosophers by fire, as the Chemists were emphatically termed, no longer exclusively engaged in seeking for the elixir of life, and the stone of transmutation, began to direct their endeavours towards more attainable and useful objects. They availed themselves of the accumulated facts collected by the misguided zeal and barren labours of their predecessors, and combined these useless and unseemly materials into the foundations of a beautiful and useful department of knowledge; but their progress was slow, and not unfrequently interrupted by relapse into the follies of Alchemy.

Glauber of Amsterdam, [1] and in this country the Honourable Robert Boyle, are characteristic writers of the middle of the seventeenth century. The former has detailed many curious and interesting facts respecting neutral salts, acids, and animal and vegetable substances; but his descriptions are darkened by the language of the adepts, and valuable truths are disguised by being blended with the unintelligible jargon of the black art.

The perusal of Glauber's chemical works leads to some surprise at the multitude of facts with which he was acquainted, and, among them, we meet with discoveries which have been considered of modern date. He particularly describes the production of vinegar during the destructive distillation of wood. (*Miraculum Mundi*, p. 1.) The following may be selected from among many similar passages in his writings, as exhibiting the active and original turn of mind of this keen and curious inquirer, and as containing the germ of many truths which have been more fully developed in our own time.

"But what other things the said juice of wood is able to effect, we cannot here declare, by reason of our intended brevity; yet this I will add, that, if this acid spirit be rectified, it may be used in the preparation of good medicines; in mechanic arts; in the making of many fair colours from the extraction of metals, minerals, and stones; and for all things for which common vinegar is used; yea, far more commodiously, because it much exceedeth common wine and beer vinegar in sharpness."

He also mentions the tar produced in the same process, which he recommends as

[1] A collection of Glauber's works, in Latin, was published at Franckfort, in 1658, in 8vo, and in 1659 in 4to. An English translation was published at London, in 1689, by C. Pack.

efficacious in preserving wood that is exposed to weather, and speaks of it, when mixed with ashes, as a profitable and quickly acting manure. He further points out the method of concentrating the vinegar of wood by exposure to cold, "which freezes the phlegm only, but the sharp spirit is not turned into ice, but remaineth in the middle of the hogshead, so sharp that it corrodeth metals like aqua-fortis. If hop-poles be dipped in the oil, it not only preserves them, but fattens the plant; and as insects abhor these hot oils, if they be applied to the bark of fruit-trees, it will defend them from spiders, ants, canker-worms, and other insects; by this means also rats and mice may be prevented from creeping up hovel-posts, and devouring the grain." Glauber details a number of experiments relating to the action of this vinegar of wood, on limestone, and notices the uses of its compounds; and that he was accurately acquainted with its superior acidity, appears from the following quotation: "It is said that Hannibal made a passage through the Alps for himself and his army, softening the rocks by the benefit of vinegar. What vinegar that was, histories do not mention. Perhaps it was the vinegar of wine; but if he had had the vinegar of wood, he might sooner have attained his desire."

These shrewd remarks and useful observations are thickly scattered through the verbose pages of Glauber. He enriched the laboratory with new agents, and into medicine he introduced several new and useful remedies. Upon the arts he bestowed many improvements, and was among the first who seriously endeavoured to benefit agriculture by the medium of experimental chemistry.

Boyle[1] has left voluminous proofs of his attachment to scientific pursuits, but his experiments are too miscellaneous and desultory to have afforded either brilliant or useful results; his reasoning is seldom satisfactory; and a broad vein of prolixity traverses his philosophical works. He was too fond of mechanical philosophy to shine in Chemistry, and gave too much time and attention to theological and metaphysical controversy to attain any excellence in either of the former studies. He who would do justice to Boyle's scientific character, must found it rather upon the indirect benefits which he conferred, than upon any immediate aid which he lent to science. He exhibited a variety of experiments in public, which kindled the zeal of others more capa-

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[1] Boyle was born in January 1627, at Lismore, in the Province of Munster, in Ireland. He was educated at Eton, and afterwards travelled in Italy, Switzerland, and France, and returned to England in 1644. In 1668 he took up his residence in London; and in 1680 was elected President of the Royal Society. He died on the 30th of December 1691, aged 65.

ble than himself. He was always open to conviction; and courted opposition and controversy, upon the principle that truth is often elicited by the conflict of opinions. His disposition was ever amiable, mild, and generous, and he was at once the patron of learning and of virtue.

The merit of bringing Hooke[1] before the public, and of pointing out to him the road to eminence, is chiefly due to Mr Boyle, who, in the troublesome and bigotted periods of the commonwealth and protectorship, associated himself with a few philosophical friends at Oxford, for the purpose of promoting experimental inquiry. Hooke, who enjoyed the advantage of having been educated at Westminster school, under Dr Busby, was introduced in the year 1655 to this select society, where his original and inventive genius was soon discerned and called into action. Boyle engaged him as his operator and assistant, and his talents were turned, with great success, to the invention and improvement of philosophical instruments, and to many important subjects connected with the mechanical arts.

It was about this period that the physical properties of the atmosphere began to attract notice, and that the favourite scholastic notion of Nature's abhorrence of a vacuum was called into question. Galileo was perhaps the first who broke this spell of Aristotelian philosophy; and in the year 1644, the grand discovery of atmospheric pressure, and its variation, was announced by Torricelli, the celebrated inventor of the barometer.[2] The idea of constructing a machine for the purpose of rarefying air, first

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1 Sir Godfrey Coply, in a letter written about the time of Hooke's death, says, " Dr Hooke is very crazy; much concerned for fear he should outlive his estate. He hath starved one old woman already, and, I believe, he will endanger himself to save sixpence for any thing he wants." In another, written a few weeks after his death, Sir Godfrey says, " I wonder old Dr Hooke did not choose rather to leave his L. 12,000 to continue what he had promoted and studied all the days of his life,—I mean mathematical experiments, than to have it go to those whom he never saw or cared for. It is rare that virtuosos die rich, and it is pity they should, if they were like him." (*Dr Ducarrel's MSS.* quoted in *Biog. Dict.*) Hooke sometimes declared, that he intended to dispose of his estate for the advancement of natural knowledge, and to promote the ends for which the Royal Society was instituted; to build a handsome edifice for the Society's use, with a library, laboratory, and repository, and to endow a professorship. (*Life by Waller.*)

2 The Peripatetics maintained, that the creation of a vacuum was impossible, even to supernatural power. This dogma was first shaken by a circumstance which happened to some workmen employed by the Grand Duke of Tuscany. Having sunk a deep well, they endeavoured to bring the water to the surface by a common sucking-pump, but found, to their surprise, that they could only make it ascend to the height of about 30 feet. Galileo, whose talents had gained him great celebrity and respect, was consulted in this emergency. His answer was, that, although nature does dislike a vacuum, there is a certain limit to her antipathy, equivalent to the pressure of a column of water eighteen palms high.

occurred to Otto Guericke, who, after many fruitless attempts, succeeded by means of a sucking pump, in withdrawing a considerable portion of air from the interior of a copper ball. With this awkward and imperfect air-pump, he performed several notable experiments. One of these is often exhibited at the present day. It consists in exhausting a hollow brass globe, composed of two hemispheres, closely fitted to each other. When a portion of the interior air is removed, the pressure of the exterior atmosphere is such as to resist considerable force applied to separate the hemispheres. This is called the Magdeburgh experiment, and was first publicly exhibited in the year 1654 before the deputies of the empire, and foreign ministers assembled at the diet of Ratisbon. This original air-pump, invented by the Burgomaster of Magdeburgh, was greatly improved by Hooke, who, in conjunction with Boyle, performed by its means a variety of new and important experiments, illustrative of the mechanical properties of the atmosphere, which, at a subsequent period, tended considerably to the progress of pneumatic chemistry.

The works of Hooke, chiefly interesting to the chemist, are his *Micrographia* and *Lampas*, the former published in 1664, the latter in 1677. They contain anticipations of many of the subsequent changes and improvements of chemical theory, which will be noticed in a future page of this history.

Both the private and public character of Dr Hooke exhibit many faults, and are stained with many blemishes. His temper was peevish, reserved, and mistrustful; and he wanted that candour and dignity of mind which should raise the philosopher above the level of ordinary men. He was born at Freshwater, in the Isle of Wight, in 1635, and died in London in the year 1702.

Immediately after the Restoration, the gentlemen who formed the Philosophical Society at Oxford adjourned to London, where they held their meetings in Gresham College, and considerably extended the number of their members. The King, who himself loved science, countenanced and patronised their proceedings; and, on the 15th of July 1662, granted a royal charter, constituting them a body corporate, under the name of *The Royal Society of London, for promoting Natural Knowledge*. In the year 1665 was published the first number of the *Philosophical Transactions*, of which work, justly regarded as the standard of English science, a volume has been published annually since the year 1762.

This laudable and rare example of Charles the Second was followed by Lewis the Fourteenth of France; and in the year 1666 the *Royal Academy of Sciences* was instituted at Paris, under the immediate protection of that monarch. Neither was the

patronage cold, nor the honours empty, which were bestowed by Lewis on the followers of science. Salaries he conferred upon scientific bodies, and pensions upon learned men, "a generosity," says Hume, "which does great honour to his memory, and in the eyes of all the ingenious part of mankind will be esteemed an atonement for many of the errors of his reign. We may be surprised," continues the historian, "that this example should not be more followed by Princes, since it is certain that bounty so extensive, so beneficial, and so much celebrated, cost not this monarch so great a sum as is often conferred upon one useless overgrown favourite or courtier." Happily for the scientific character of Britain, the genius, talents, and exertions of individuals have ever been sufficient to counterbalance such advantages; and thus nurtured and protected, the growth of science has not been less rapid or vigorous than where she has enjoyed the sunshine of royal favour.

With the great and unrivalled name of Newton, we close the records of the seventeenth century. To him Chemistry is indebted for the first correct views respecting the nature of combination; a subject which had little engaged the attention of the more sensible experimentalists of the preceding periods, and which was formerly attributed to the occult qualities of the Aristotelians, and afterwards to the mechanical forms of the particles of bodies.[1]

Chemical affinity was referred by Newton to the different attractive powers of the different kinds of matter in regard to each other. Salt of tartar becomes moist by exposure to air, because that salt attracts the humidity of the atmosphere. Muriatic acid unites with salt of tartar by virtue of their respective attractions; but when oil of vitriol is poured upon this compound, the former acid is displaced by the superior attraction of the latter. Silver dissolved in aqua-fortis is separated from that menstruum by the superior attraction of quicksilver; in like manner copper separates quicksilver; and iron, copper. Referring to these and other similar instances, "does not this" says he "argue, that the acid particles of the aqua-fortis are attracted more strongly by iron than by copper, by copper than by quicksilver, and by quicksilver than by silver?" Such are the simple but clear, and, in most instances, correct suggestions relating to the subject of attraction, which Chemistry owes to the great luminary of Mechanical Philosophy.

In tracing the history of Chemistry from early times, through the dark ages, to the

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[1] We shall again have occasion to refer to certain chemical opinions of Newton. In the present instance, reference is made to the thirty-first query annexed to the *Third Book of Optics.* (Newton, *Opera Omnia*, 4to, Lond. 1782.)

beginning of the last century, I have only noticed such authors as conduced by the weight or novelty of their writings, the importance of their discoveries, or the example of their zeal, to the more immediate progress and elucidation of this department of philosophy. The annals of a period so extensive must necessarily record a host of experimentalists, to whose researches it would upon the one hand be impossible to do justice; and whose names, on the other, it would be useless to repeat. It may however be remarked, that alembics, and other complex distillatory apparatus, were employed by the alchemical physicians who flourished between the ninth and thirteenth centuries. Mesue mentions the distillation of rose-water, and the production of spirit of wine is noticed by Raymond Lully. At this time, too, furnaces of peculiar construction, and a variety of complex apparatus and accoutrements, were introduced into the laboratory.

During the fifteenth and sixteenth centuries, Alchemy was at its acmé, and many were the unwary and avaricious who were entrapped by the golden prospects and plausible mysticism of the art. Among them was that admirable artist Mazzuoli of Parma, better known under the name of Parmagiano.

Curious discoveries and useful inventions multiplied rapidly during the seventeenth century. Kunckel, in Saxony, successfully promoted the Chemistry of the Arts. In 1669, Brandt of Berlin discovered Phosphorus, and about the same time Homberg accidentally produced a spontaneously inflammable compound, which he called Pyrophorus. In 1674 the elder Lemery acquired great and deserved fame at Paris as a chemical lecturer. He was the first who threw aside the affected and pompous diction habitually indulged in by his predecessors and contemporaries, and adopted a simple and perspicuous style, which at once tended to the ready diffusion of his subject, and to its permanent popularity. When he published his course, "it sold" says Fontenelle "like a novel or a satire."

The establishment of literary and scientific societies during this age was another grand step towards the promotion of knowledge, and the period was particularly propitious to their progress. Bacon, Galileo, and Kepler, had opened that road to truth which was so eagerly and successfully pursued by Boyle, Hooke, and Mayow, in this country, and in which the miraculous mind of Newton displayed its brilliant powers. In Germany, Beccher and Stahl are entitled to particular mention. The suggestions of the former, who was a man of an acute and inquisitive turn of mind, led the latter into that train of speculation which terminated in producing the Phlogistic Theory, and which will presently be more particularly considered. Homberg, Geoffroy, and

the two Lemerys, were zealous followers of experimental chemistry in France, at the establishment of the Royal Academy of Sciences. In short, the independent zeal and healthy activity in scientific pursuit, which has since marked its progress in Europe, became manifest early in the seventeenth century; and the causes I have attempted to unfold contributed to the splendour which it began to acquire about the end of that important era in the general history of the world. The clouds of ignorance and error quickly dispersed before this happy dawn of true knowledge; and science, no longer enveloped in scholastic mystery and absurd speculation, began to display those inherent charms, which gained her the courtship and admiration of every liberal and cultivated mind, and which laid the foundation of that extended dominion which she acquired in the succeeding age. [1]

SECTION II.

STATE OF CHEMISTRY AT THE OPENING OF THE EIGHTEENTH CENTURY.—OPINIONS OF BECCHER AND STAHL RESPECTING THE PHENOMENA OF COMBUSTION, COMPARED WITH THE VIEWS OF REY AND MAYOW.—PNEUMATIC CHEMISTRY OF HAILES AND BOERHAAVE.—INVENTION OF THE THERMOMETER.

The history of the progress of Chemistry during the seventeenth century presents many active and able inquirers, whose researches tended to develope new properties and combinations of bodies; but their attempts at theory and generalization were, with few exceptions, absurd and abortive. They consisted in wild hypothesis and vague speculation, and were founded, not upon the sober and steady basis of truth, but upon the unreal and tottering visions of the imagination. The spirit of Lord Bacon was slow in animating experimental philosophy, until Newton rose to surprise and illumine the world. It then assumed a new and cheerful aspect, and quick was its growth, and illustrious its progress, under the invigorating influence of that sun of science.

Although Chemistry does not lie under the same weighty obligations to Newton as

[1] Those who are desirous of consulting the alchemical authors, and of becoming particularly acquainted with the titles of their voluminous productions, will find a curious body of information on these subjects in the *Histoire de la Philosophie Hermetique*, Paris, 1742.—Gobet's *Anciens Mineralogistes*, published at Paris in 1779, gives some details of the early progress of Mineralogical Chemistry in France.

mechanical philosophy, he conferred upon it a great and lasting benefit, by the disclosure of those clear and simple views which have already been alluded to.[1] The important deductions, too, which flow in easy perspicuity from his experimental researches, soon became general models of imitation; and the new style which we discern in the philosophical authors of the early part of the eighteenth century throughout Europe, may, in a great measure, be referred to the lofty example before us.

No sooner was the spell of Alchemy broken, than the phenomena of combustion began to attract the notice of the early chemical theorists. The influence of the air upon this process had been long observed, and many of the changes suffered by the com-

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[1] The following passages, in addition to the previous observations in the text, will be sufficient in illustration of Newton's views of *Elective Attractions*.

"Have not the small particles of bodies certain powers, virtues, or forces, by which they act at a distance, not only upon the rays of light, for reflecting, refracting, and inflecting them, but also upon one another, for producing a great part of the phenomena of nature? for, it is well known, that bodies act one upon another by the attractions of gravity, magnetism, and electricity; and these instances show the tenor and course of nature, and make it not improbable that there may be more attractive powers than these. For nature is very consonant and conformable to herself. How these attractions may be performed I do not here consider; what I call attraction may be performed by impulse, or by some other means unknown to me. I use that word here to signify only, in general, any force by which bodies tend towards one another, whatsoever be the cause. For we must learn from the phenomena of nature what bodies attract one another, and what are the laws and properties of the attraction, before we inquire the cause by which the attraction is performed. The attraction of gravity, magnetism, and electricity, reach to very sensible distances, and so have been observed by vulgar eyes, and there may be others which reach to so small distances as hitherto escape observation, and perhaps electrical attraction may reach to such small distances even without being excited by friction. For, when salt of tartar runs *per deliquium*, is not this done by an attraction between the particles of the salt of tartar and the particles of the water which float in the air in the form of vapours? And why does not common salt, or saltpetre, or vitriol, run *per deliquium*, but for want of such an attraction? Or why does not salt of tartar draw more water out of the air than in a certain proportion to its quantity, but for want of an attractive force after it is satiated with water? And whence is it but from this attractive power that water, which alone distils with a gentle and lukewarm heat, will not distil from salt of tartar, without a great heat? And is it not from the like attractive power, between the particles of oil of vitriol and the particles of water, that oil of vitriol draws to it a good quantity of water out of the air; and, after it is satiated, draws no more, and in distillation lets go the water very difficultly? And when the water and oil of vitriol, poured successively into the same vessel, grow very hot in the mixing, does not this argue a great motion in the parts of the liquors? And does not this motion argue that the parts of the two liquors, in mixing, coalesce with violence, and, by consequence, rush towards one another with an accelerated motion? And when *aqua-fortis*, or spirit of vitriol, poured upon filings of iron, dissolves the filings with a great heat and ebullition, is not this heat and ebullition effected by a violent motion of the parts?" &c. "When spirit of vitriol, poured upon common salt or saltpetre, makes an ebullition with the salt, and unites with it, and, in distillation, the spirit of the common salt or saltpetre comes over much easier than it would do before, and the acid part of the spirit of vitriol stays behind;—does not this argue that the fixed alcaly of the salt attracts the acid spirit of the vitriol, more strongly than its own spirit; and, not being able to hold them both, lets go its own?"—Newton's *Optics*, Opera omnia, 4to, Lond. 1782.

bustible had been examined with a surprising degree of acuteness and precision; for fire was almost the only agent employed at that period to effect combination and decomposition. These inquiries constitute a prominent feature in the history of Chemistry. It may therefore be requisite to pursue them with a minute attention, which may at first appear tedious, but which will gain in importance and interest as they proceed.

The first speculations in theoretical Chemistry deserving attention, are those of John Joachim Beccher of Spires, who died in England in 1685. He gained considerable celebrity at Vienna and Haerlem, for improvements in arts and manufactures, but was induced to retire to this country, in consequence of the jealousy of rivals, and the neglect of those upon whom he had conferred benefits. His works abound in shrewd and witty remarks, and in deep and curious reasoning,—in frivolous subtilty, and in weighty and sensible observations. His hypothesis respecting the origin of the varieties of matter, from the mutual agencies and combinations of a few elementary principles, though unnecessarily blended with scriptural history, are characterized by considerable brilliancy of thought and originality of invention. They are detailed at great length in his *Physica Subterranea*, which treats on the original creation of matter, and the transition and interchange of elements. The *Institutiones Chemicæ*, or *Œdipus Chemicus*, of this author, is another curious production, containing the history of the chemical elements, and describing the leading operations of the laboratory. Earth was the favourite element of this philosopher, of which he supposed three varieties to exist, namely, a vitrifiable, a metallic, and an inflammable earth. Of these the various productions of nature were formed. [1]

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[1] Beccher wrote voluminously upon a great variety of subjects. His principal chemical works are as follows.

1. *Oedipus Chemicus.* 2. *Metallurgia, de generatione, refinatione, et perfectione Metallorum.* 3. *Physica Subterranea*, and its various appendices. 4. *Parnassus Medicinalis Illustratus.* 5. *Laboratorium Portatile.* 6. *Chymischer Rosen-garten.*

Beccher's *Oedipus* is dedicated to Francis Sylvius Deleböe, who, in 1658, was elected the first Professor of Medicine in the University of Leyden. He was a man of an acute mind, as appears from his various essays and tracts, more especially from his *Praxeos Med. Idea Nova.* He died at Leyden in 1672. "Utilissimum profecto munus subiisti, quo tui auditores non verba sed corpora, non chymerasticos terminos, verum ipsas reales enchyrises, non inanes denique et immateriales facultates, sed a te demonstrati, effectus causas practicas audiunt, vident, tangunt." Beccher everywhere compliments him as a man not of words, but of deeds; as a philosopher, who eminently sought to render science popular and intelligible to all capacities.

The language of Beccher's *Physica Subterranea* is sufficiently inelegant and incorrect. "Excuso *Latini-*

But the most celebrated chemical theorist of the latter part of the seventeenth century is Ernest Stahl, born at Anspach in Franconia, in 1660. He adopted many of the opinions of Beccher respecting the cause of inflammability, and upon these foundations reared the celebrated System of Phlogiston, according to which, inflammability is supposed to depend upon the presence of a highly subtile and elastic matter, which, at certain temperatures, is thrown into violent motion, and appears under the form of flame or fire. Combustion is the separation of this principle, and bodies contain it in various proportions. Charcoal, for instance, when burned, leaves scarcely any residuum, and is, therefore, nearly pure phlogiston. Antimony, when burned, affords a large proportion of earthy matter. If this earth be heated with charcoal, or other matter abounding in phlogiston, antimony is regenerated; this metal, therefore, is a compound of earth and phlogiston.

If sulphuric acid, which is not inflammable, be distilled with oil of turpentine, which is extremely so; or, in other words, if phlogiston be added to sulphuric acid, sulphur is obtained. Sulphur, therefore, is a compound body, consisting of sulphuric acid and phlogiston. If sulphur and common potash be fused together, a brown compound is obtained, formerly called liver of sulphur, and the same product results when charcoal is heated with Glauber's salt, which consists of soda combined with sulphuric acid. Such was Stahl's explanation of the phenomena of combustion, and such the apparently plausible experimental proofs upon which it was founded. [1]

In Germany and in France, the phlogistic doctrine was received with that thoughtless and eager enthusiasm which suffers the blaze of novelty to eclipse the steady light of truth, and which is rather captivated by plausible exterior than by internal excellence. Even in this country the experiments of Boyle and of Hooke, if not forgotten, were over-

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tatem in hoc opere," says he, " quam *barbaram* esse fateor, ob materiem et ob scriptionem, in specie scriptionis modum: ex ore enim dictantis totum opus conceptum est. Sic *rebus* attentus, *verba* neglexi." This is at once an example and apology.

[1] Stahl's doctrines are very ably set forth in his *Three Hundred Experiments*, published at Berlin in 1731; and in his *Fundamenta Chemiæ*, Nuremberg, 1723 and 1732. He observed the necessity of air to combustion, and considered flame or fire as resulting from its violent etherial agitations. Stahl is continually urging circumspection in hypotheses, yet preconceived opinions are always leading him to erroneous conclusions, as the following passages amply prove. " Aer ignis est anima, hinc, sine aere nihil potest accendi vel inflammari."—" Aer in motum excitatus, seu ventus artificialis, vel etiam naturalis, mirum excitat motum ætheris, seu flammam; hinc ad ignem fusorium, et vitrificatorium, promovendum, follibus opus est; imo gradus et vehementia ignis dependet multum ex aeris admissione." *Fund. Chem. dogmat. et ration.* p. 22.

looked, and hypothesis for a time gained the ascendancy over facts; for it had been most satisfactorily demonstrated by those experimentalists, that bodies will not burn if air be excluded, and that, during combustion, a portion of the air is consumed by the burning body. Even at an earlier period, the same observation had been most pointedly dwelt upon and another equally important circumstance ascertained, namely, the increase of weight sustained by metals during their calcination. As early as 1629, Brun, an Apothecary, resident in the town of Bergerac in France, melted two pounds six ounces of tin, and in six hours the whole was converted into a calx, which weighed seven ounces more than the tin employed. Brun, surprised at this circumstance, communicated it to John Rey,[1] a physician of Perigord, who, in 1630, published a Tract upon the subject, in which he refers the increase of weight to the absorption and solidification of air: "Thus," says Rey, in the fanciful language of the period, "have I succeeded in liberating this surprising truth from the dark dungeons of obscurity; which was vainly but laboriously sought after by Cardan, Scaliger, Faschius, Cæsalpinus, and Libavius. Others may search for it, but in vain, unless they pursue the royal road which I have cleared. The labour has been mine,—the profit is the reader's,—the glory is from above."

But amongst the authors whose researches tended to conclusions diametrically opposite to those of Stahl and his associates, and whose writings abound in anticipations of modern discoveries, no one stands so conspicuous as our countryman John Mayow.[2] His tracts, published at Oxford in 1674, relating to chemical, physiological, and medical subjects, abound in traits of original and inventive genius, and furnish the prototype of many discoveries, which have conferred great and lasting renown upon succeeding labourers in the field of Chemistry. It is the treatise upon nitre and the nitro-ærial spirit to which I principally allude, and of which it may be proper to give a short but connected sketch.

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1 *Essays* de Jean Rey, Docteur en Medecine, *sur la Recherche de la Cause pour laquelle l'Estain et le Plomb, augmentent de poids quand on les calcine*." Paris, 1777.

Of these curious essays, originally printed in 1630, a copy was discovered in the Royal Library at Paris in 1776. The scarcity of the first edition is in some measure accounted for in the "Advertisement" to the present, but the rarity of this reprint is very enigmatical.

2 Mayow was born in Cornwall in 1645, and died in London in 1679, at the early age of thirty-nine. Dr Beddoes and Dr Yeats have asserted Mayow's claims to several modern discoveries; and in many other instances than those quoted in the text, he has certainly anticipated both the discoveries and inventions of some of his chemical successors. All Mayow's tracts are deserving of attentive perusal, and are of full knowledge. The first and second, *De Sal-nitro et Spirito Nitro-ærio* and *De Respiratione*, contain a vast body of chemical facts, resulting from well conceived and conducted experiments.

The atmosphere, he observes, contains a certain nitro-saline matter, a spirit, vital, igneous, and fermentative, which exists in, and may be obtained from nitre; that it supports combustion, but is itself incombustible; that it exists in nitric acid; that when antimony is exposed to the joint operation of heat and air, it imbibes the nitro-ærial particles, whence its increase in weight; and that a similar change may be effected by nitre or by nitric acid; that acidity depends upon the absorption of the same principle which in sulphuric acid is combined with sulphur, either during combustion, or during the exposure of pyrites to air: that fermentation is referable to a very similar cause: that it is necessary to vegetation, and present in all cases of combustion; that it is absorbed by animals during respiration; and that the same substance which contributes to the support of flame, is likewise required for the support of life. Mayow also was acquainted with the evolution of air during the action of nitric and vitriolic acids upon iron, and points out a mode of collecting it, in bottles inverted in vessels of the dilute acids. He observes that the air generated in these experiments, although expansible by heat, is probably different from the atmosphere, as is also the air which an animal has breathed, and in which a candle has burned.

These are a few of the important facts dwelt upon by Mayow, respecting the nature of the atmosphere, and of the cause of combustion. That they were not at the time opposed to the purely speculative notions of Stahl is truly remarkable, for they explain, in conjunction with the observations of Rey and others, the great obstacle to the phlogistic hypothesis, the increase of weight in the burning body; they show the real cause of the necessity of the presence of air, which, if combustion consisted in the mere evolution of the subtile principle of fire, could not be required; and they adduced experimental evidence, where Stahl merely surmised.

Another active inquirer occurs in this page of chemical history; one whose researches cleared the way for the great discoveries of the succeeding era, and to whom the merit is justly due of having opened a mine in the field of nature; who indulged, not in the speculative and metaphysical frivolities which characterize the productions of most of his predecessors, and many of his contemporaries, but followed nature with a steady and unerring step, and recorded his observations in a concise, unadorned and unaffected style. This was the Reverend Dr Stephen Hales.[1] He was the first

[1] Born in 1677; died in 1761. Dr Hales is one of the few divines who have employed their abundant leisure in philosophical and experimental researches. It is said that he refused high preferment upon more

who instituted researches into the physiology of vegetation, a subject which he pursued with considerable ardour and perseverance. He also made a variety of experiments upon the extrication of air during the exposure of animal, vegetable, and mineral substances to heat. In perusing his Essays on these subjects, we frequently find him upon the verge of those splendid discoveries which fell to the lot of his fellow-labourers and successors ; but the erroneous nature of his preconceived opinions induced him to take for granted that which experiment should have determined, and to rest satisfied with results which, had they been followed up, would inevitably have led to the most important and novel facts. His experiments do credit to his industry, but his conclusions betray feebleness of judgment. If, instead of regarding the various gaseous products obtained from the substances he operated upon, as consisting of common air contaminated by their effluvia, he had submitted them to more close investigation, he would doubtless have run a more brilliant and successful career. He is justly regarded as the founder of Pneumatic Chemistry, but he contributed few materials to the superstructure.

Herman Boerhaave, [1] of Leyden, who was a contemporary of Hales, pursued a

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than one occasion, in order that he might attend to his humble parochial duties, and continue his scientific pursuits.

He directed his attention to the quantity of moisture imbibed and emitted by different plants, and to the circulation of the sap, which, he says, put him upon making a more particular inquiry into the nature of a fluid which is so absolutely necessary for the support of the life and growth of animals and vegetables.

His *Specimen of an Attempt to analyse the Air by Chymiostatical Experiments* displays extraordinary ingenuity in the contrivance of experiments and apparatus. It was his misfortune to consider the various gases which he procured as mere modifications of atmospheric air. *Philos. Trans. Statical Essays*, London, 1731.

[1] Boerhaave was born in December 1668, at a village near Leyden. He died in September 1738. He was an eminent ornament of medicine, as well as of chemical science. His oration upon resigning the office of Governor of the University of Leyden has been justly eulogised by Johnson. (*Life of Boerhaave.*) He here declares in the strongest terms (says his eloquent biographer) in favour of experimental knowledge, and reflects with just severity upon those arrogant philosophers, who are too easily disgusted with the slow methods of obtaining true notions by frequent experiments, and who, possessed with too high an opinion of their own abilities, rather choose to consult their own imaginations than inquire into nature, and are better pleased with the charming amusement of forming hypotheses than the toilsome drudgery of making observations.

The emptiness and uncertainty of all those systems, whether venerable for their antiquity, or agreeable for their novelty, he has evidently shown ; and not only declared, but proved, that we are entirely ignorant of the principles of things, and that all the knowledge we have is of such qualities alone as are discoverable by experience, or such as may be deduced from them by mathematical demonstration.

Boerhaave's contributions to physic were large and valuable. His principal chemical work is the *Elementa Chemiæ*, of which a good translation, with notes, was edited in 1753 by Dr Shaw. This work he

similar train of inquiries; but, although many of his experiments were new and well conceived, he was not more happy in his conclusions, nor more fortunate in his discoveries. He attributed the elasticity of air to its union with fire, and considered its ponderable matter as susceptible of chemical combinations; but the existence of different aeriform fluids escaped his notice.

The philosophers whose names have been now recorded, not only greatly added to the stock of chemical facts collected by their predecessors, but conferred new life and vigour upon the science by their occasional incursions into the regions of theory and rational speculation:—in this light, the works of Rey, Mayow, and Stahl, deserve particular attention; the two former for correctness and precision, the latter for boldness and ingenuity.

About this period the Thermometer was brought to perfection, which tended materially to the progress of that most refined and difficult branch of Chemical Philosophy, relating to the nature and effects of heat. The researches, on this subject, will presently form an important feature in our history, which renders it proper to notice this instrument of such consequence in their prosecution.

That bodies change in bulk, with variations of temperature, must have been noticed at a very early period; but there can be little doubt, that the idea of constructing an instrument for measuring these variations first occurred to Santorio,[1] Professor of Medicine, in the University of Padua, in the beginning of the seventeenth century; he is also celebrated for his Medico-statical experiments, which are well burlesqued in one of the early numbers of the *Spectator*.[2]

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dedicated to his brother, who was intended for the medical profession, but went into the church; while Boerhaave, who originally studied divinity, relinquished it for physic and chemistry. Alluding to this circumstance, " Providence," says he, " has changed our views, and consigned you to religious duties, while I, whose talents were unequal to higher objects, am humbly content with the profession of physic."

In the *Elementa*, and in several of his Orations, are admirable remarks upon the useful application of Chemistry to other branches of knowledge. His observations upon its usefulness and necessity to the medical practitioner, may be well enforced at the present day; for, excepting in the Schools of London and Edinburgh, Chemistry, as a branch of education, is either entirely neglected, or, what is perhaps worse, superficially and imperfectly taught. This is especially the case at the English Universities, and the London Pharmacopœia is a record of the want of chemical knowledge, where it is most imperiously required.

[1] Santorio was born in 1561 at Capo d'Istria, on the borders of the Gulf of Trieste. He died at Venice in 1636. His *Ars de Statica Medicina* was published at Venice in 1614. Much merit is due to the steady perseverance with which he opposed the occult remedies of the empirics of his day.

[2] No. 25. By Addison.

Santorio's thermometer consisted of a tube, blown at one end into a bulb, and with the other open extremity immersed into water. In cold weather the confined air contracted and the water rose in the tube—in a warm atmosphere the air expanded and the fluid fell. Santorio observed some other particulars connected with the operation of this thermometer, among which the increased influence of the sun's rays, when the bulb was blackened, deserves notice.

The Academicians del Cimento, whose early labours have already been mentioned, materially altered and improved the thermometer, by employing a liquid to measure temperature, instead of air, the changes of bulk in which, in a moderate range of temperature, are so considerable as to render the instrument extremely bulky and otherwise inconvenient. They generally used spirit of wine, and fixed a scale of degrees to the tube, with a view to ascertain its variations in bulk with greater precision. These instruments soon acquired considerable celebrity, and were largely circulated under the appellation of the Florence Glass. In this state the uses of the thermometer were extremely limited, no two instruments corresponded, and there being a free communication between the fluid and the external air, it was liable to evaporation,—yet was this thermometer much preferable to the over-sensible and bulky instrument of Santorio. There was another objection to spirit of wine, arising out of the readiness with which it assumes an elastic state, and which renders it unfit for measuring temperatures even below the heat of boiling water. Sir Isaac Newton, therefore, suggested the use of linseed oil, which, however, is extremely ill adapted to the purpose on account of its unctuosity, and the ease with which it solidifies. Quicksilver was first recommended by Roemer, [1] the eminent Danish philosopher, who discovered the motion of light; it was also employed by Dr Halley, and is now generally used. The advantages of this fluid metal in the construction of the thermometer are manifold; it retains its liquid state at very high and very low temperatures, and has the peculiar excellence of expanding very equally for equal increments of heat, which is far from the case with spirit of wine.

But the great improver of the thermometer was Fahrenheit, [2] a merchant of Dantzic, who, having failed in business, and being attached to chemical and mechanical pursuits, was obliged to gain a livelihood by making and selling these instruments. Fahrenheit used both spirit of wine and quicksilver, and hermetically sealed the tube containing the fluid; he also greatly improved the method of graduation, by establishing

[1] Born at Arhusen in Jutland, in 1644,—died at Copenhagen in 1710.

[2] Born at Dantzic in 1686,—died in 1724.

two points as the extremes of his scale, and subdividing the intermediate portion into a given number of degrees.

The division of the thermometric scale had occupied the attention of several learned and ingenious men; but it was Fahrenheit who pointed out the most accurate means of accomplishing this purpose. The curious circumstance of the water running from melted snow being always of the same temperature, appears first to have occurred to Güricke of Magdeburgh, but was first applied to the graduation of thermometers by Sir Isaac Newton. Dr Hooke had observed that the quicksilver in the tube of the thermometer, plunged into boiling-water, always rose to the same height; accordingly, if a mercurial thermometer be put into melting snow, and the point at which the fluid stands, marked upon the tube, and then transferred to boiling-water, and that point also marked, and if the intermediate space be subdivided into any number of equal degrees, 100 for instance, it follows that, provided proper precautions have been taken in selecting and filling the tube, every thermometer so constructed will indicate the same degree, when applied to bodies of the same temperature. With regard to the boiling point, Fahrenheit observed it to differ under different degrees of atmospheric pressure, and pointed out the necessity of fixing it at a mean barometrical altitude. He had also noticed, that a degree of cold much more intense than that of ice might be procured by a mixture of snow and salt; and conceiving this to be extreme cold, he commenced his scale from that point, which is 32° below the freezing of water. Accordingly, Fahrenheit's scale commences at 0°, the temperature of his freezing mixture; the freezing point of water is marked 32°, and the boiling point 212°; the space between the freezing and boiling of water being divided into 180°. The graduation of thermometers received its greatest improvement in 1742, by Celsius of Sweden, who commenced the scale at the freezing of water, and divided the space between it and the boiling point into 100°. This is the centigrade scale, now used in France. Reaumur's scale, in which the point of congelation is marked 0°, and that of boiling-water 80°, is used in some parts of the European Continent; and in Russia the descending scale of Delisle is sometimes employed, in which the boiling point of water is 0°, the freezing 150°. These scales have each their merits and defects. In the event of innovation, the interval between the freezing and boiling of mercury, might be divided into 1000 equal parts; the former being 40° below 0° of Fahrenheit, the latter about + 670°. The degrees would thus be sufficiently small to be expressed without fractions; and the commencement of the scale,

which is about the lowest natural temperature, would be so low, as to preclude the frequent necessity of expressing negative degrees. [1]

From this sketch of the history of the thermometer, it is obvious, that its operation depends upon the circumstance of fluids diminishing in bulk by diminution of temperature, and the contrary; which is really the case with all fluids except water. This important fact was observed by the Florentine Academicians in their early experiments, and it is among the most curious and interesting discoveries of that zealous and active association of experimentalists. Having filled a large thermometer tube with water, they plunged it into a mixture of salt and snow. The water presently began to contract in bulk, and descend in the tube; but, instead of continuing to do so, till it reached the freezing point, after a short time it commenced expanding; the expansion went on till a portion of the water froze, and was then very suddenly increased. [2]

The temperature at which water thus begins to expand by cooling is 40° Fahrenheit, and water cooled down to 32°, that is, 8° below 40°, occupies the same space as

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[1] This proposal is suggested by Mr Murray. *System of Chemistry*, Vol. I.

[2] The following unaffected narrative of this celebrated experiment is very different from the usual verbose and pompous style of the philosophers of the period.

"Già sapevamo per innanzi (e lo sa ognuno) che il freddo da principio opera in tutti i liquori ristrignimento, e diminuzione di mole, e di ciò non solamente n'avevamo la riprova ordinaria dell' aquarzente de' Termometri, ma n'avevamo fatta esperienza nell' acqua, nell' olio, nell' argentovivo, ed in molt' altri fluidi. Dall' altro canto sapevamo ancora, che nel passaggio, che fa l'acqua dall' esser semplicemente fredda al rimuoversi dalla sua fluidità, e ricever consistenza, e durezza coll' agghiacciamento non solo ritorna alla mole, ch' ell' aveva prima di raffreddarsi, ma trapassa ad una maggiore, mentre se le veggon rompere vasi di vetro, e di metallo con tanta forza. Ma qual poi si fosse il periodo di queste varie alterazioni, che in essa opera il freddo, questo non sapevamo ancora, ne era possibile d'arrivarvi con agghiacciarla dentro a' vasi opachi, come quei d'argento, d'ottone, e d'oro ne' quali s'era fin' allora agghiacciata: Onde per non mancare di quella notizia, che parea esser l'anima di tutte quest' esperienze, ricorremmo al cristallo, ed al vetro, sperando per la transparenza della materia d'aver presto ad' assicurarci come la cosa andasse, mentre si poteva a ciascun movimento, che fosse apparso nell' acqua del collo, cavar subito la palla dal' ghiaccio, e riconoscer in essa quali alterationi gli correspondessero. Ma la verità si è, che noi stentammo assai più che non ci saremmo mai dati ad intendere, prima di poter rinvenire alcuna cosa di certo intorno a' periodi di questi accidenti. E per dirne più distintamente, il successo è da sapere, che nella prima immersione, che facevamo della palla, subito, ch'ella toccava l'acqua del ghiaccio s'osservava nell' acqua del collo un piccolo sollevamento, ma assai veloce, dopo il quale con moto assai ordinato, e di mezzana velocità s'andava retirando verso la palla, finchè arrivata a un certo grado non proseguiva più oltre a discendere, ma si fermava quivi per qualche tempo, a giudizio degli occhi, affatto priva di movimento. Poi a poco a poco si vedea ricominciare a salire, ma con un moto tardissimo, e apparentemente equabile, dal quale senz' alcun proporzionale acceleramento spiccava in un subito un furiosissimo salto, nel qual tempo era impossibile tenele dietro coll' occhio, scorrendo con quell' impeto, per così dire, in istanti le decine e le decine de' gradi." *Esperienze intorno al progresso degli artifiziali agghiacciamenti, e de' loro mirabili accidenti*. Saggi di naturali esperienze fatte nell' accademia Del Cimento." Firenze, 1691.

when heated to 8° above 40°; in other words, the density or specific gravity of water is at its maximum at 40°.

When in the year 1683 Dr Croune repeated this experiment before the Royal Society, Hooke attributed the effect, not to any peculiarity in the expansibility of water, but to a rapid and sudden contraction of the glass bulb, which would force the water upwards in the tube;[1] a conclusion amply disproved by other forms of the experiment, especially by that suggested by Dr Hope[2] of Edinburgh, in which a freezing mixture was applied to the surface of water at 60° contained in a tall cylindrical glass jar. The water was cooled throughout to 40°, and then the surface sunk to 32°, and froze. But when the freezing mixture was applied to the bottom of the jar, the water became cooled throughout to 32°. If the cold be applied to the centre of the vessel, as long as the water is above 40°, the warmer part will always be at the top, but below 40° the arrangement is reversed, and the warmer part being then most dense, occupies the lower half of the vessel, and the colder portion floats upon it.

The influence of this singular anomaly, which has thus been demonstrated by unanswerable experiments, is of great extent and importance. In most of the cases in

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[1] The *Histories of the Royal Society* by Sprat and Birch, contain a curious body of experimental evidence on a great variety of philosophical subjects, and detail the opinions and observations of many eminent persons upon the various researches that were carried on before that learned body. The business of the Society was formerly conducted upon a very different plan from that now pursued, and much resembled the present proceedings of the Academy of Sciences of the Royal Institute of France.

The following is Dr Birch's memorandum relating to this experiment:

February 6, 1683.

A letter of Mr Musgrave to Mr Aston, dated at New College, Oxford, was read, containing, among other things, several experiments about freezing, as that two inches of water in a tube $\frac{1}{2}$ inch diameter, expanded itself, upon freezing, $\frac{5}{6}$ higher; that a tube one inch diameter filled 6 inches, rose upon freezing, $\frac{7}{8}$ of an inch; and that half a pint of water, upon freezing, lost in weight ʒij. ℈ij. gr. viij.

Dr Croune said, that having weighed three ounces of water, he found it, after freezing, to differ a scruple and half.

Sir Christopher Wren remarked, that if water were suddenly frozen, there would be less difference in weight.

Dr Croune said, that he observed water which he had put into a bolt-head, to rise higher before there was anything of freezing in it.

Mr Hooke attributed the rising of the water in the neck of the bolt-head, to the shrinking of the glass.

Dr Croune said, that the glass had been long in the cold, before, and that the water rose immediately.

Dr Wallis proposed, that an empty glass might be cooled well in a freezing liquor, in order that it might have its contraction before the water be put into it.

This was done immediately by Mr Hunt, and the water being put into a small bolt-head, rose about ** of an inch in the neck, though the air at that time was very warm. (Birch's *History of the Royal Society*. Vol. IV. p. 253.)

[2] *Edinburgh Transactions*, Vol. VI.

which nature deviates from her usual established laws, philosophy has discovered happy consequences in her aberration; and where such discovery has not been made, investigation should be upon the alert to trace the clue that is presented.

If water were obedient to the same laws of refrigeration as other less universal liquids, such as spirit, oils, and quicksilver, it must be evident, that, during the winter's cold, our rivers and lakes, instead of presenting a superficial stratum of ice, would soon become solid throughout; the continuous influence of the summer's sun would be required to produce their fluidity, and the inhabitants of the waters would annually risk extermination.

These effects are obviated by the peculiarity observed by the Academicians del Cimento. As the temperature of the earth is in winter always greater than that of the atmosphere, the cooling of large bodies of water must take place from above, by the contact of cold air and chilling blasts. The whole mass will thus be lowered to 40°, after which, the water becoming specifically lighter as it becomes colder, remains upon the surface where it sinks to 32°, and is converted into a film of ice, which being a bad conductor of heat, thickens slowly, and affords further protection to the warmer fluid beneath. Those who in winter's cold accidentally fall through the ice, are surprised by the comparative warmth of the water below, and the aquatic animals that in summer sport upon the surface of their element, retire in winter to the more genial retreats which nature has thus provided.

In tracing the progress of Chemistry through its dark and early periods, the historian necessarily traverses a rugged and barren path; his chief object must be to advance, and the shortest is generally the safest road. Reaching the age of Alchemy, the prospect, though improved, is not such as to demand a very deliberate survey: its fictions, however, like those of romantic chivalry, have somewhat of reality for their basis, and by the mere increase of experimental inquiry, contributed essentially to the growth of chemical knowledge. As a science, its progress was languid until the middle of the seventeenth century, when it began to shake off the lethargy in which it had been sunk, and was turned with eager curiosity to new and more useful objects.

In the dross of the alchemical furnaces many scattered treasures were discovered, the value of which was greatly enhanced by arrangement and systematic combination. New views were thus opened to the Experimentalist; and authors, dismissing the florid exuberancies and pompous affectation of their predecessors, cultivated an unadorned and simple style, more becoming the dignity of scientific narration.

These circumstances contributed to confer a prosperous aspect on Chemical Philo-

sophy at the commencement of the eighteenth century. It was applied to the arts, and to them it gave an unexpected and vigorous impulse. It was directed to the investigation of nature, and there it discovered new beauties. It found "tongues in trees, books in the running brooks, sermons in stones, and good in everything."

SECTION III.

DISCOVERIES OF DR BLACK, RELATING TO THE CAUSE OF CAUSTICITY IN EARTHS AND ALKALIES, AND TO CERTAIN PHENOMENA OF HEAT.

The discoveries of Dr Joseph Black form a most important epoch in the history of Chemical Philosophy; they embrace two leading subjects,—the one relating to the causticity of the earths and alkalies—the other to the operation of heat in changing the state of bodies; in rendering solids liquids; and converting liquids into elastic or aeriform fluids.

Regarding these researches as isolated specimens of inductive philosophy, they have rarely been equalled: as influencing the progress of Chemistry, by disclosing the hidden cause of many very intricate phenomena, they have never been surpassed; and, by a happy combination of circumstances, we trace in them the distant but fertile source of those gigantic improvements of the arts, in which the perfection of the steam-engine is involved.

Of a man whose scientific character is thus pre-eminent, and in whose attainments his country has just reason to exult, history has recorded a brief but interesting memorial. [1]

Dr Joseph Black was sprung from a Scottish family, transplanted first to Ireland and then to France, where he was born in 1728, on the banks of the Garonne. When twelve years of age, he was sent for education to Belfast, and afterwards to the University of Glasgow, where he entered upon the study of Physic, under the guidance of that bright ornament of medical science, Dr William Cullen. In 1750 he removed to Edinburgh; four years afterwards, he took the degree of Doctor of Physic; and, in

[1] Dr Robison's Preface to Black's *Lectures on the Elements of Chemistry*.

1756, published his Experiments on Magnesia, Quicklime, and some other alkaline substances, in the *Physical and Literary Essays.* In the same year Dr Cullen, having removed to Edinburgh, Dr Black returned to Glasgow to fill the Medical and Chemical chair of that University, where he was received with open arms both by the Classes and Professors. In 1764, he brought his ideas respecting the combinations of heat with ponderable matter to perfection. Speculations upon this subject had occupied his mind during a considerable period, but the difficulties of the inquiry, and the time necessarily consumed in other professional avocations, had considerably interfered with the pursuit.

In 1766, he was appointed to the Chemical Chair of Edinburgh, an office which he filled with such talent, industry, and perseverance, as not only drew an immense concourse of hearers to his class, but tended to confer upon chemistry a degree of popularity and importance, which has been greatly conducive to its promotion and extension. "His discourse," says his biographer, Professor Robison, "was so plain and perspicuous, his illustrations by experiment so apposite, that his sentiments on any subject never could be mistaken; and his instructions were so clear of all hypothesis or conjecture, that the hearer rested on his conclusions with a confidence scarcely exceeded in matters of his own experience." [1] In short, Dr Black, in his professorial capacity, was entitled to every praise, and he contributed most essentially to the foundation and increase of the reputation which the University of Edinburgh has acquired and maintained. Nor was his private character at variance with his public excellence; he was mild, amiable, and fond of conversation, whether serious or sportive; and he was not above uniting to the highest philosophical attainments, most of the

[1] Dr Black's character as a lecturer is given by his friend Professor Robison in the following terms:—"He endeavoured every year to render his courses more plain and familiar, and to illustrate them by a greater variety of examples in the way of experiments. No man could perform these more neatly and successfully. They were always ingeniously and judiciously contrived, clearly establishing the point in view, and never more than sufficed for this purpose. While he scorned the quackery of a showman, the simplicity, neatness, and elegance with which they were performed, were truly admirable. Indeed, the *simplex munditiis* stamped every thing that he did. I think it was the unperceived operation of this impression that made Dr Black's Lectures such a treat to all his scholars. They were not only instructed, but (they knew not how) delighted; and without any effort to please, but solely by the natural emanation of a gentle and elegant mind, cooperating indeed with a most perspicuous exhibition of his sentiments, Dr Black became a favourite lecturer, and many were induced, by the report of his students, to attend his courses, without having any particular relish for chemical knowledge, but merely in order to be pleased. This, however, contributed greatly to the extending the knowledge of Chemistry, and it became a fashionable part of the accomplishments of a gentleman." *Preface*, p. li.

elegant accomplishments of life. In his advanced age he often expressed a hope that he might not linger in protracted sickness, on account of the distress which, in such cases, is suffered by attending friends; and his death, which happened in his 71st year, in November 1799, is on this account the more remarkable. He was taking some milk and water, and having the cup in his hand, when the last stroke of his pulse was to be given, had set it upon his knees, and in this attitude expired without the smallest agitation.

The writings of Black, though lamentably few, are masterpieces of scientific composition. Newton was his model, and he was the first who transferred into chemistry the severe system of inductive logic, which marks the productions of that great master of natural philosophy. "In no scientific inquiries, since the date of the *Principia* and *Optics*, do we find so great a proportion of pure ratiocination, founded upon the description of common facts, but leading to the most unexpected and important results, as in the two grand systems of Black." Averse to all hypothesis, and aware of the multitudinous facts upon which a theory that is to stand firm must be founded, Dr Black was unwarrantably slow in the formal public disclosure of his admirable researches. His tenets were fully and freely delivered to his pupils; but he very rarely intruded upon the public as an author; and his splendid achievements in the philosophy of heat are chiefly developed in his posthumous works. This silence, arising out of an over-cautious modesty which marked all his proceedings, was not favourable to the reputation of Dr Black. Faulty and incomplete copies of his lectures were circulated among his friends and admirers, which afterwards reached the hands of those who deserve another name, and by whom they were not very honourably employed.

The first researches of Dr Black, which it will be necessary to attend to, explain the cause of causticity in earths and alkalies. When chalk or limestone, which are mild insoluble tasteless substances, are heated to redness in the open fire, they are converted into quicklime, a body corrosive, soluble in water, and having an acrid flavour. Stahl, Macquer,[1] and Meyer, attributed this change to some substance absorb-

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[1] Macquer was born at Paris in 1718, and died in 1784. He ranks among the most eminent scientific Chemists of the early part of the eighteenth century; and though involved in the errors of the Phlogistic school, he has written with much good sense and perspicuity on a variety of chemical subjects. His most celebrated works are, the *Elemens de Chimie Theorique*, Paris, 1749; and *Elemens de Chimie Pratique*, Paris, 1751. He also published a Chemical Dictionary. The following is all his information respecting the property possessed by quicklime of rendering the alkalies caustic. After describing the process, he observes, "Le but de cette operation, est de réunir avec le sel alcali fixe ce que la chaux a de salin et

ed from the fire,—to an acrid acid,[1]—to phlogiston, and other creatures of the imagination. Dr Black's mind was turned to this subject in consequence of the discovery of magnesia. This substance made its first appearance as an Arcanum in Italy, in 1707. Valentine showed that it might be obtained from the mother-liquor of nitre, but it was supposed to be lime, until Hoffman, in 1720, pointed out several peculiarities by which it is distinguished from that earth. Hoffman prepared magnesia from bittern, or the saline liquor which remains after the separation of common salt from sea water; to this he added an alkali which precipitated the earth.[2] The substance which thus exists in bittern, is a compound of magnesia and sulphuric acid. It was first obtained from certain mineral springs in the neighbourhood of Epsom in Surry, and thence called Epsom salt, but was sold at a very high price, in consequence of the small quantities so procured, until the manufacturers in the neighbourhood of Lymington obtained it from sea water; it was then largely exported to the Continent under the name of English salt.

Epsom salt was indeed long confounded with Glauber's salt, and a fraud of the manufacturers here, and in Germany, tended to keep up the confusion; for at that period Glauber's salt was rare in England, and large crystals of Epsom salt were sold under that name; but in Germany, where Epsom salt was not common, Glauber's salt, in

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d' âcre."——" On le combine avec la partie la plus âcre, la plus subtile, et la plus saline de la chaux."——" Nous n'entreprendrons point ici d'expliquer pourquoi le sel alcali, que l'on combine avec la chaux, acquiert une si grande causticité. *Cette question nous paroît une des plus delicates et des plus difficiles à résoudre que nous offre la Chimie.* Elle tient à celle des propriétés alcalines de la chaux, et on ne peut guères espérer de la résoudre, que quand on aura acquis sur la nature de cette substance, beaucoup plus de lumières que nous n'en avons à présent." *Elemens de Chimie Pratique,* pp. 179. 182.

[1] J. F. Meyers, *Chemische versuche zur nähern erkenntniss des ungelöschten kalks; der elastischen und electrischen Materie, des allerreinsten feuerwesens, und der ursprünglichen allgemeinen säure.* Hannover, 1764. In this dissertation, though published subsequently to Black's essay, the causticity of the alkalis and lime is referred to the absorption of a principle which the author calls *Causticum,* or *Acidum pingue.* Between the years 1760 and 1772, a great variety of dissertations were published in Germany upon this question, some in support of Black's doctrine, others in favour of Meyers's hypothetical absurdities. See Gren's *Systematisches Handbuch der Gesammten Chemie.* Halle, 1794. § 437.

[2] *Observ. Phys. Chem.* 1722.

Hoffman was the most celebrated Chemical Physician of the age. He was born at Halle in Saxony, in 1660, and died in 1742. His writings, which are voluminous, are also valuable. In 1749, they were eked out by the Genevese Booksellers into nine folio volumes. The following are his leading Essays in Chemistry:

Dissertationes de Generatione Salium,—De Natura Nitri,—De Cinnabare Antimonii,—De Mirabili Sulphuris Antimonii fixati efficacia,—De Mercurio et Medicamentis Mercurialibus. Observationum Physico-Chemicarum Collectio. Libri iii.

small crystals, was vended as English or Epsom salt. Pott of Berlin, and Du Hamel of Paris, were led into a comedy of errors in consequence of mistaking the nature of these bodies.

Dr Black found that, when magnesia was prepared by precipitating a solution of Epsom salt by a mild alkali, that it effervesced with acids; but that when heated to redness it lost weight, and then dissolved without effervescence. This fact, which also holds good in respect to lime, induced him to believe that, instead of gaining any thing in the fire, something was lost by these earths. He, therefore, distilled some magnesia in a retort, but found, that although it lost weight as before, nothing but a relatively small quantity of water was found in the receiver. The experiments of Dr Hales now rushed into his mind, and it occurred to him, that some gaseous or aeriform body had escaped from the earth, and that this was the cause of its effervescing with acids,—a circumstance previously ascribed to the collision of the acid and earthy particles. He therefore put some magnesia not calcined into a bottle, with a bent tube attached to it; and thus, during the action of the acid, obtained a large quantity of an elastic fluid, in a vessel inverted in water; he found, too, that chalk, and common alkali, yielded the same kind of air. The air thus existing in these substances Dr Black called fixed air; and he proved it to be the cause of mildness in earths and alkalies. If lime be added to a mild alkali, the lime absorbs its fixed air, and renders it caustic,—an effect formerly attributed to the transfer of the fiery particles of the lime.

In the year 1750, Venel observed that selters, and other sparkling waters, when placed under the receiver of an air-pump, gave out a large quantity of air, and became flat and insipid, and he imitated them by dissolving common soda in water, and adding muriatic acid, which produced an effervescence and gave it briskness. [1] These experiments were a little antecedent to Dr Black's publication, but they by no means anticipated his discoveries. [2] In 1764 the conclusions of Black were verified, and his

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[1] "En 1750, Venel, Professeur de Chimie à Montpellier, reprit le fil de ses expériences en arretant dans l'eau le fluide dégagé des effervescences, et en imitant ainsi, par sa dissolution artificielle, les eaux minérales acidules; *mais il fit encore tous ses efforts pour prouver que c'etoit de l'air.*" Fourcroy, *Histoire*, p. 28.

[2] Dr Brownrigg of Whitehaven threw out some curious hints respecting fixed air, or, as it is now called, carbonic acid, as early as 1765. In a communication to the Royal Society, printed that year in their *Transactions*, he remarks, "that a more intimate acquaintance with those noxious airs in mines, called *damps*, might lead to the discovery of that subtile principle of mineral waters, known by the name of their *spirit;* that the mephitic exhalations termed the Choak-damp, he had found to be a fluid permanently elastic; and, from various experiments he had reason to conclude, that it entered the composition of the

views extended, by Dr Macbride of Dublin, who pointed out several new properties of fixed air, and demonstrated its existence in the atmosphere; for lime exposed to air gradually loses its causticity, and becomes effervescent. The operation of quick-lime as a manure depends upon its power of rendering the inert vegetable matter of the soil soluble and fit for the nourishment of young plants; an effect which it does not produce when combined with fixed air, or in the state of chalk: hence the lime should be spread quickly over the land, and not left in heaps exposed to the air, by which, as Dr Macbride has shown, it is rendered mild, and of comparatively small effect. [1]

Such are the principal features of Dr Black's researches respecting the cause of mildness and causticity in earthy and alkaline substances. They constitute an important body of chemical evidence, and are established upon the satisfactory basis of analytic and synthetic proofs.

I now turn to his more elaborate investigation into the effects of heat; to inquiries so momentous in their influence upon the advancement of experimental philosophy, so replete with difficulties, and so masterly in their execution, as to raise them to the highest efforts of the human mind. I have deemed a rapid glance at the discovery of fixed air sufficient for our present purpose; for occasions will afterwards offer of descanting more largely upon its nature and properties; but the investigation now before us, is that from which the towering and durable greatness of Black's name has been principally derived; and it was begun, continued, and completed, by the labour of his own hands.

In speaking of the graduation of thermometers, it was mentioned, that if snow or ice be brought into a warm atmosphere, and suffered to thaw slowly, the water which

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waters of Pyrmont, Spa, and others, imparting to them that pungent taste, from which they were denominated *acidulæ*, and likewise that volatile principle on which their virtues chiefly depend."

Mr Lane was the first who ascertained the solubility of iron in water, impregnated with fixed air. *Phil. Trans.* 1769. "By this means," says Sir John Pringle in his discourse on the different kinds of Air, delivered at the anniversary meeting of the Royal Society, November 30, 1773, "the nature of the metallic principle in mineral waters was clearly explained, and the whole analysis of those celebrated fountains, so often attempted by Chemists and others, and still eluding their laboured researches, was thus, in the most simple manner, brought to light."

[1] Macbride's *Experimental Essays*, 1764. The merit of this performance induced the University of Glasgow to bestow the degree of Doctor of Physic on the author.

Dr Macbride introduced some important improvements into the art of Tanning, and was the first who employed lime water in the preparatory operations of that process. He was born in the county of Antrim in 1726, and died in 1778.

runs from it is always at one temperature, that of 32° of Fahrenheit's scale. This and similar cases seem to have occupied the early thoughts of our philosopher; for his biographer informs us, that, in the oldest parcels of his notes, he found queries relating to this subject. How does it happen that, although heat is constantly flowing from surrounding bodies to the ice, its temperature is not increased? Water at 32°. when brought into a room at 60°. goes on increasing in temperature till it attains that of the circumambient air; but the ice, though exposed to exactly similar sources of heat, remains at 32°. Why, when water is cooled several degrees below its freezing point, does its temperature suddenly rise to that point, the instant that it congeals? or why is it, that, when a vessel of water is put upon the fire, a thermometer plunged into it continues to indicate increase of heat until it rises to 212°; and the water then boils, but does not become hotter, although it remains upon the fire, and has all its former opportunities of acquiring heat? Such were the queries which Dr Black has most happily resolved.

In regard to the liquefaction of ice, he has demonstrated that, when solids pass into the liquid state, the change is always accompanied with the absorption of heat, which is concealed or becomes latent in the liquid, and is not indicated by the thermometer, which instrument, therefore, is no measure of the absolute quantity of heat. A variety of interesting and curious experiments were undertaken with a view to ascertain the quantity of thermometric heat, which thus becomes latent during the conversion of ice into water. A pound of snow at 32° was mixed with a pound of water at 172°; the snow was melted, and the temperature of the mixture was only 32°; so that here 140° of thermometric heat had disappeared; their effect being, not to raise the temperature of the snow, but to convert it into water. We should say, therefore, from this experiment, that water at 32° is a compound of ice, and 140° of heat as indicated by the thermometer. If water, at the temperature of 32°, be mixed with an equal weight of warm water, suppose at 200°, the resulting temperature will be the mean; $232 \div 2 = 116$; but if we use ice, the temperature will not be the mean, for 140° of heat must be subtracted from the warm water, which heat is consumed in liquefying the ice; the result, therefore, will be the same as if water at 32° and 60° were mixed, giving a mean of only 45°.

These experiments at once demonstrated the cause of many facts respecting the production of heat and cold, which, though long known, remained without any plausible explanation.

When solids become fluids, the production of cold is more or less evident, according to the rapidity of the change. Those saline bodies, for instance, which are very rapidly soluble in water, generate during their solution a considerable intensity of cold, for to become fluid they must absorb heat. When snow and salt are suddenly blended, there is an instant liquefaction, and the temperature of the substances being already low, a degree of cold equal to 0° of Fahrenheit is obtained. The production of cold by mixing snow and muriate of lime, a very soluble salt, is —40° Fahrenheit, and sufficient to freeze quicksilver even in a comparatively warm atmosphere. A mixture of 5 parts of sal ammoniac in powder, and 5 parts of nitre with 16 of water, sink the thermometer from 50° to 10°. Equal parts of nitrate of ammonia and water produce a more intense cold, and by a clever successive application of these freezing mixtures, the intense degree of cold of — 91°. Fahrenheit has been artificially exhibited. This is 123° below the freezing of water, and 40° below the greatest natural cold hitherto observed, which was at Hudson's Bay, where the spirit thermometer has been seen at 50°.

There are many counter illustrations of this doctrine of latent heat; in which heat is evolved during the conversion of liquids into solids. If oil of vitriol be poured upon magnesia, there is a sudden solidification of the acid by its union with the earth, and a considerable rise of temperature ensues. Water poured upon quicklime produces a similar phenomenon; and when water at perfect rest is exposed in a covered vessel to an intensely cold atmosphere, its temperature may be reduced to many degrees below its freezing point: A slight agitation causes it suddenly to become ice, and at that instant the temperature rises to 32°. A somewhat similar case is the sudden crystallization of saline solutions, during which their latent heat becomes sensible to the feeling, and is indicated by the thermometer.

In Dr Black's theory of latent heat, it is assumed that heat is matter; that it is a substance of excessive tenuity, existing in variable proportions in bodies; that when in a free state it affects our senses, and the thermometer, but that it occasionally enters into union with other substances, or is separated from them, consistent with the usual laws of chemical attraction. Thus, in fluids, it is combined or latent, but when they are converted into solids, it is separated in a free or sensible state. The other view of the question represents heat as the result of a vibrating motion among the particles of bodies; the vibrations being most rapid and extensive in the hottest bodies. In fluids the vibrations are accompanied by a motion of the particles round their own axes; and when solids pass into the fluid state, the vibratory motion or temperature is in part lost, by the communication of the rotatory motion to the particles.

Each of these hypotheses has had its able defenders and advocates; the ideas of Newton seem to have been favourable to the latter, and many facts may be adduced in its support. The strongest are the imponderability of heat, and its continuous extrication by friction. That we discover no increase of weight in a heated body may be attributed to the insufficiency of our instruments, but its unlimited production in a variety of cases, though consonant with the hypothesis of vibration, ill agrees with that of a specific form of matter.

If a soft iron nail be beaten upon the anvil, it becomes hot and brittle, and it cannot again be rendered malleable till it has been resoftened by exposure to the fire. By those who favour the notion of a matter of heat, this has been called an *experimentum crucis.* The matter of heat, say they, is squeezed out of the nail, as water out of a sponge, but it is reabsorbed in the fire. In this experiment, however, it must be recollected, that the mechanical arrangement of the particles of the iron is considerably altered; it is rendered very brittle; and hence, perhaps, its insusceptibility of becoming again hot till restored to its former state or texture by the expansive power of fire.

It was not until the publication of the researches which have just been considered, that a variety of curious circumstances concerning congelation were understood. The gradual progress in the freezing of large bodies of water has been shown to depend in some measure upon the remarkable anomaly respecting its maximum of density; but it is also materially connected with the phenomena of latent heat; for water, before it can become ice, must part with a quantity of heat, which, if suddenly evolved, would raise the thermometer 140°. It must also be obvious, that the process of thawing suffers a similar retardation, for ice requires for its conversion into water, the absorption of 140°. of sensible heat.

Thus we see that sudden congelation and sudden liquefaction are alike prevented; that the process must be gradual, and consequently productive of none of those evils which would result from a more rapid change.

One of the great advantages of irrigation, or meadow watering, is also explained by a reference to these principles. In an irrigated meadow, the surface of the water may be frozen; but as water at 40° is heavier than at 32°, the former will be its temperature in contact with the grass; and it is a temperature perfectly congenial to the functions of vegetable life. Sir Humphrey Davy examined the temperature in a water meadow near Hungerford, in Berkshire, by a very delicate thermometer. The temperature of the air, at seven in the morning, was 29°. The water was frozen above the grass; the temperature of the soil at the roots of the grass was 43°. Thus, by the peculiarity in the re-

frigeration of water, by the defence afforded by the stratum of ice, and by the laws of congelation, the vegetables are not merely protected from the effects of an intensely cold atmosphere, but likewise from the injurious influence of sudden changes of temperature.

Congelation is to surrounding bodies a source of heat, and there is no inconsiderable mitigation of the extreme cold of air wafted over large bodies of water, by the transfer of latent to sensible heat, which must occur before they can freeze.

The theory of freezing mixtures has led to considerable improvements of their applications, and many new and curious discoveries have resulted in pursuing this inquiry. Indeed, whatever tends to disclose the laws of nature cannot ultimately fail of subjecting her more or less to the uses of life, and of manifesting more and more the wisdom of the Creator.

Having established the above facts respecting the cause of fluidity, Dr Black proceeded to the second part of his inquiry, relating to vaporisation, and pursued it with the same abilities and success. [1] Finding the thermometer to remain stationary at 212° in boiling water, he conceived the process of ebullition to be in some respects analogous to that of liquefaction, and that the heat which did not raise the temperature of the water, entered into union with it, and became latent in the steam. If this

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[1] "When we heat a large quantity of a fluid in a vessel, in the ordinary manner, by setting it on a fire, we have an opportunity of observing some other phenomena which are very instructive. The fluid is gradually heated, and at last attains that temperature which it cannot pass without putting on the form of vapour. In these circumstances, we always observe, that it is thrown into the violent agitation which we call boiling. This agitation continues as long as we throw in more heat, or any of the fluid remains, and its violence is proportional to the celerity with which the heat is supplied.

"Another peculiarity attends this boiling of fluids, which, when first observed, was thought very surprising. However long and violently we boil a fluid, we cannot make it in the least hotter than when it began to boil. The thermometer always points at the same degree, namely, the vaporific point of that fluid. Hence the vaporific point of fluids is often called their Boiling point.

"When these facts and appearances were first observed, they seemed surprising, and different opinions were formed with respect to the causes upon which they depend. Some thought that this agitation was occasioned by that part of the heat, which was more than the water was capable of receiving, and which forced its way through, so as to occasion the agitation of boiling; others, again, imagined, that the agitation proceeded from air, which water is known to contain, and which is now expelled by the heat. Neither of these accounts, however, is just or satisfactory; the first is repugnant to all our experience in regard to heat: we have never observed it in the form of an expansive fluid like air: it pervades all bodies, and cannot be confined by any vessel, or any sort of matter; whereas, the elastic matter of boiling water, can be confined by external pressure, as is evident in the experiments made with Papin's digester."

This quotation from Black's *Lectures*, (Vol. I. p. 153.), is inserted to show the state of the argument respecting the phenomena of ebullition previous to his researches.

were the case, it should be re-evolved during the condensation of steam; and thus a method was devised of ascertaining its thermometric quantity. Dr Black's experiments on this subject were very numerous. I shall allude to such as put the phenomenon in the clearest light, and are perfectly unconnected with hypothesis.

He noted the time consumed for raising a certain quantity of water to its boiling point, and then kept up the same heat till the whole was evaporated, and marked the time consumed by the process. It was thus easily computed what the temperature would have been, supposing the rise to have gone on above 212° in the same ratio as below it. The water was originally at 50°; it boiled in four minutes, and in twenty minutes was all evaporated. In four minutes, therefore, it had gained 162° for $50^\circ + 162 = 212$; and in twenty minutes would have gained $162 \times 5 = 810^\circ$; which may, therefore, be considered as the equivalent thermometric expression of the latent heat of the steam. Another good illustration of the absorption of heat in the production of steam, is furnished by heating water under compression. It may then be raised many degrees above its ordinary boiling point; but, on removing the pressure, a portion of steam rushes out, and the remaining water has its temperature lowered to 212°.[1]

Hence we learn, that the conversion of water into vapour is attended with a great loss of heat to the surrounding bodies; and although the perceptible temperature of water and steam are identical, the latter contains heat equivalent to between 800 and 900° of perceptible or thermometric temperature. When steam is reconverted into water, this large quantity of heat is again given out; and hence a small portion of steam is capable of heating a large body of water to its boiling point. The knowledge of this fact is of great economical importance; and in breweries and other manufactories, where large bodies of water are required to be boiled, the steam, instead of being suffered, as formerly, to pass off into the air, is conveyed by pipes into other vessels of water, which it heats during its condensation. In the same way, rooms and houses are warmed by the heat evolved during the condensation of steam, in iron or copper tubes which traverse the building, and the method is at once safe and effectual.

It is in consequence of the latent heat of steam, that, in the process of distillation, we are obliged to present so large a surface for condensation; and it is not difficult, by the help of a still, to calculate the latent heat of steam. If, for instance, one hun-

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[1] See Black's Experiments, which prove the absorption of heat. *Lectures*, Vol. I. p. 157, &c.

dred gallons of water at 50° be mixed with one gallon at 212°, the temperature of the water will be raised above $1\frac{1}{2}^{\circ}$. If, by the common still-tub, one gallon of water be condensed from the state of steam by one hundred gallons of water at 50°, in that case the water will be raised 11°, which is about $9\frac{1}{2}^{\circ}$ degrees more than in the former instance. Hence it appears, that the heat imparted to a hundred gallons of cold water by eight pounds of steam, would, if it could be condensed into one gallon of water, raise it 950°.

The average of the various experiments which have been made on this subject, warrants us in placing the latent heat of steam between 900° and 1000°.

These facts demonstrate that the condensation of vapour is always a heating process, and that its formation must equally be attended with the production of cold.

[1] About the year 1774, it was observed by Dr Cullen, that a thermometer moistened with spirit of wine or ether, sinks many degrees during the evaporation of those fluids; with others, the thermometer may be made to fall from 60° to 0°. The cause of this is sufficiently explained by Dr Black's theory; the ether and spirit readily pass into vapour, which reqnires a certain quantity of heat for its production; this is taken from the bodies it happens to be in contact with, as from the thermometer or the hand; hence the cold perceived when these fluids are applied to the body, and the advantage which results from their application in cases of burns, and inflammations. These circumstances led Dr Cullen to accelerate the evaporation of these fluids, by exposing them under the receiver of the air-pump; by placing a flask half full of ether

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[1] "The Chemistry of Stahl, as it was cultivated in Germany, and France, and other countries of Europe, scarcely aspired beyond the bounds within which it had been circumscribed by its original founder. A few important facts, indeed, were added, but they were either connected with medical preparations, or attracted attention solely as objects of curiosity. The great and tempting field of Philosophical Chemistry lay unexplored, when it was entered upon with ardour by Dr Cullen, who first peceived its value, and whose genius and industry, had they not been turned into another channel, would, in all probability, have been crowned with the richest discoveries. But though Dr Cullen soon abandoned his chemical pursuits for those of medicine, he was fortunate enough to have initiated into the science a man whose discoveries formed an era in chemistry, and who first struck out a new and brilliant path, which was afterwards fully laid open, and traversed with so much eclat by the British philosophers who followed his career. This fortunate pupil of Dr Cullen, was Dr Joseph Black." *Thomson, History of the Royal Society*, p. 468.

Dr Cullen's fame as a promoter of chemistry has been lost in his greater celebrity as a teacher of medicine. "Chemistry," says his biographer, Dr Anderson, "which was, before his time, a most disgusting pursuit, was, by him, rendered a study so pleasing, so easy, and so attractive, that it is now pursued by numbers as an agreeable recreation, who, but for the lights that were thrown upon it by Cullen and his pupils, would never have thought of engaging in it at all."

Cullen was born in Lanarkshire in 1712, and died at Edinburgh in 1790.

in a tumbler of water, it was found that, during the process of exhaustion, the evaporation was so rapid from the ether in the flask, as to convert the surrounding water into ice.[1]

This part of the philosophy of heat, regarded in its connection with the phenomena of nature, opens pleasing views of her order and economy. In the constant evaporation from the earth's surface, from rivers, lakes, and the sea, we discern an unfailing cause of equalization of heat; the vapour thus formed, ascending to colder regions, there becomes a source of increase of temperature, and, re-assuming fluidity, is thrown upon the earth in fertilizing showers, or forming torrents among the mountains, and rivers in the valleys, is returned to the parent ocean, and again becomes active in a similar cycle of changes.

But besides these obvious and complete changes in the state of matter connected with the evolution or absorption of heat, there are others in which similar alteration of temperature is observed, without a positive change of form. Whenever the density of a body, whether solid, liquid, or aeriform, is varied, there is an equivalent variation in its latent heat. The specific gravity of soft iron is increased by hammering, and heat is evolved during the operation. A piece of Indian rubber, suddenly extended, becomes warm. If water be mixed with oil of vitriol, the density of the water is increased, and there is a very considerable augmentation of temperature. If air be suddenly compressed, it retains its elastic state, but becomes violently heated; on the other hand, if air be quickly rarified, there is an equivalent reduction in its tempera-

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[1] Dr Cullen's paper is published in the *Physical and Literary Essays and Observations*. Edinburgh, 1756. Vol. II. It contains the details of many interesting experiments upon the production of cold, and he considers the power of fluids in this respect, as nearly according to the degree of volatility in each. "If to this," says he, "we join the consideration that the cold is made greater by whatever hastens the evaporation, and particularly that the sinking of the thermometer is greater, as the air in which the experiment is made is warmer, if dry at the same time, I think, we may now conclude, *that the cold produced is the effect of evaporation*."

A very curious and ingenious method of accelerating the evaporation of water, so as to produce a freezing temperature, has lately been devised by Professor Leslie. If we place a small basin of water under the receiver of the air-pump, its temperature will sink a few degrees during exhaustion. If a large surface of oil of vitriol be at the same time included in the exhausted receiver, the vapour of the water is rapidly absorbed by that fluid, the perfection of the vacuum is thus maintained, the production of vapour is extremely rapid, and the quantity of heat absorbed for its formation so considerable, as to allow of the conversion of the remaining water into ice. Other absorbents, such as dry clay, oatmeal, &c. may be substituted for the acid. The operation of wine and water coolers, and all cases in which diminution of temperature results from evaporation, are admirably explained upon Dr Black's *Theory of Latent Heat*.

ture. In these cases, bodies are said to change their capacities for heat; increase of density is attended with a diminution of capacity for heat; and diminution of density with an increased capacity. The phenomena thus presented are such as the doctrine of latent heat would lead us to expect. When a fluid is converted into a solid, there is a copious evolution of heat; when a fluid approximates to a solid state, or where its density is increased, we might expect that heat would also be evolved.[1]

The last train of investigation, in regard to heat, which occupied Dr Black's thoughts, related to the different quantities of heat contained in different substances of the same temperature, without relation to change of density or state. A reference to an experiment will perhaps render this point more intelligible. If, for instance, a given quantity of boiling water, surrounded with ice, in sinking from 212°. to 32°. melts one pound of ice, and if the same quantity of olive oil, in passing from the same to the same temperature melts only half a pound of ice, we should conclude, that, although the thermometric temperature of the two fluids is similar, the actual quantity of heat contained in the water, and ascertainable by its effects upon the ice, is twice that contained in the oil. To signify the quantity of heat thus contained in different bodies of the same temperature, the term *specific heat* has been employed—we thus should state, from the result of the experiment alluded to, the specific heat of water to be 2, that of olive oil 1. Irvine, Crawfurd, Wilcke, Lavoisier, and several eminent Experimentalists of the present day, have engaged themselves in researches on this subject, but the inquiry originated with Dr Black, in the year 1762.

In these limited observations upon the discoveries of Black, I hope to have rendered myself intelligible upon those main points of his investigations, which constitute the foundation of some of the most important and refined doctrines of chemical science. The distinct object of this discourse being to record the march of chemical discovery, and not to unfold the principles of the science, it would be unwise to indulge in more extended incursions upon this fertile ground, or to trace the great trunk of his researches to its extreme ramifications. But a partial glance at the facts disclosed will show even a superficial observer the obligations we are under to the discoveries of this eminently modest and unassuming Philosopher. Of many of the most intricate phenomena of nature they furnished new, easy, and luminous explanations; and to the arts

[1] The sinking of a thermometer suspended in the receiver of the air-pump, during exhaustion, and its subsequent rise upon the readmission of air, are noticed by Dr Cullen in the paper just quoted.

they were of unparalleled benefit; for, by developing their connection, not with the shallows merely, but with the depths of science, a new road was opened to their improvement and perfection.

Among the learned lookers-on of this period we discern many who, with independent and liberal minds, loved and patronized science for its own sake, and they were pleased at its rapid progress under the auspicious guidance of Black. Others, actuated by motives illiberal and interested, countenanced science solely upon the selfish principle of gain; the puerile and short-sighted question of *cui bono* was constantly on their lips; but even they have been silenced by the application of Black's discoveries.[1]

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[1] This may be the proper place to show in what way the views of Dr Black's *Theory of Latent Heat* are connected with the improvements of the steam-engine—a subject upon which I must necessarily be brief, as only in part belonging to the object of this discourse. The Marquis of Worcester is commonly regarded as the inventor of the steam-engine, but his claims are not well authenticated. It is true, that, among the Utopian schemes to be found in his Century of Inventions, there is a dark description of a method of raising water by steam; but we can scarcely see how this was effected, nor are there any data recorded of the success of the contrivance. Be this as it may, he who barely and obscurely hints the possibility of an undertaking cannot be regarded as forestalling him who successfully carries it into execution; and the first person, who, upon decided evidence, constructed an engine for raising water by the alternate force and condensation of steam, was Captain Savary,—who also published an account of his invention in a small tract called the *Miner's Friend.* To enter into a description of this instrument would be irrelative to my present purpose; I therefore pass on to that of Newcomen, who, in 1705, obtained a patent for an improved steam-engine. It consisted of a boiler having a cylinder placed upon it, in which was a solid plunger connected by its rod with a beam and lifting pump. The plunger was elevated by the elastic force of steam admitted from the boiler. The steam-cock being closed, a small stream of cold water was suffered to run into the cylinder, by which the steam was condensed; the pressure of the atmosphere then acting upon the surface of the plunger, forced it to the bottom of the cylinder, whence it was again raised by the readmission of steam, and so on. In 1717, Mr Henry Beighton became an improver of the steam-engine; he was probably the first who caused the steam-cock to be opened and shut by the machinery, for a man was obliged to attend Newcomen's engine for this express purpose. A few other improvements were made by different persons, but they did not affect the general action of the engine; the steam was alternately admitted into, and condensed in the main cylinder; and although defects in its power had been noticed, their cause was unknown until 1765, when, happily for the prosperity of the arts and manufactures of this country, the subject engaged the keen ingenuity of Mr Watt. The model of a Newcomen's engine fell into his hands to be repaired, and in this he presently observed the immense loss of steam occasioned by its admission into the cylinder just cooled for condensation; indeed, he went so far as to ascertain, by experiment, that half the steam of the boiler was thus lost. For, having constructed a boiler which showed the quantity of steam expended at every stroke of the engine, he found that it many times exceeded that which was sufficient to fill the cylinder. But the circumstance that excited his greatest surprise was, that the injection water gained infinitely more heat than if a quantity of boiling water, equal to that required to form the steam, had been added to it. It was probably in this dilemma that he consulted Dr Black—and the explanation of the difficulty will be obvious from the facts detailed in the text. To avail himself, therefore, of the whole power of

SECTION IV.

RESEARCHES RELATING TO THE COMPOSITION OF ATMOSPHERIC AIR.—EXPERIMENTS OF RUTHERFORD AND OF PRIESTLEY.

Of the various discoveries, which it is the object of this Dissertation to unfold, none have been more important in their consequences than those relating to the composition of atmospheric air, a subject which the ancients seem not to have thought upon, since they regarded it as an element or ultimate principle of matter.[1] In this, as in most other branches of experimental science, the advances of the human mind

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the steam, it became absolutely necessary to keep up the temperature of the cylinder constantly at the boiling point of water; this he was enabled to attain, by connecting with it another vessel, exhausted of air, and immersed in cold water, into which, when communicated with the cylinder, the steam, being an elastic fluid, instantly rushes and is condensed, and, on closing its connection with the cylinder, the steam, again admitted there, now operates with full force, and suffers no further condensation. To carry off the water from this second vessel, which he calls the condenser, and to perpetuate the vacuum, Mr Watt attached to it a pump by which both the air and condensed water are removed. The engine thus altered produced the same power as one of equal dimensions on Newcomen's plan, with rather less than one-third the quantity of steam; hence was a considerable hindrance to the use of the engine materially diminished, namely, the expence of fuel. But great as was this improvement, it forms a small part of the successful achievements of Mr Watt in this department of mechanics; he amended the apparatus for boring the cylinders, and improved every part of the working gear of the engine; and he infinitely extended its applications and utility, by applying the power of steam to produce motion round an axis; but their enumeration would lead me out of the bounds of chemistry. I, therefore, hasten to the invention which may be said to have perfected the steam-engine. Steam had hitherto only been used to force the piston down,—it was returned by a weight attached to the other end of the beam. Mr Watt, in 1782, constructed an engine in which steam was used to elevate as well as to depress the piston, an alternate vacuum being formed above and below it, by the condenser, as before. An engine upon this plan, executed at Mr Watt's manufactory at Soho, near Birmingham, was first employed at the Albion Mills in 1788.

An excellent sketch of the history of the steam-engine will be found in the *Edinburgh Review*, Vol. XIII. p. 311.

[1] Thus Lucretius,—

> Aera nunc igitur dicam, quid corpore toto
> Innumerabiliter privas mutatur in horas:
> Semper enim, quodquomque fluit de rebus, id omne
> Aeris in magnum fertur mare, qui nisi contra
> Corpora retribuat rebus, recreetque fluenteis,
> Omnia jam resoluta forent, et in aera vorsa,
> Haud igitur cessat gigni de rebus, et in res
> Recidere assidue, quoniam fluere omnia constat.
>
> *De Rerum Natura*, Lib. V. v. 274.

have been very gradual: Mayow, in 1674, was upon the very brink of that stream of discovery, which, in 1774, carried Dr Priestley into the fastnesses of Pneumatic Chemistry. Hales, by showing the mode of disengaging and collecting gaseous fluids, removed many of the most serious obstacles which encumbered this path of research; he was followed by Boerhaave, and afterwards by Black, who, having reached the discovery of fixed air, turned into another road of investigation. Neither Mayow, therefore, nor Hales, nor Boerhaave, nor Black, were very diligent cultivators of Pneumatic Chemistry; they had, indeed, opened the mine, but did not explore it; its treasures were reserved for those whose labours we are now about to recount, and were chiefly borne away by the diligent dexterity of Dr Joseph Priestley.

If we trust the quotations of Rey already cited, the necessity of air, in the process of combustion, was not only observed, but inquired into by Cæsalpinus[1] and Libavius,[2] as far back as the sixteenth and early part of the seventeenth century. Mayow insisted that a part only of the atmosphere was concerned in the phenomena of combustion, and found that air in which bodies had burned became unfit for the respiration of animals.[3] As soon as it had been ascertained that, in the phenomena of combustion and respiration, a portion of fixed air was generated, the extinction of burning bodies, and the death of animals immersed in air, thus rendered foul, were referred to the presence of that gaseous body, its noxious qualities having been amply proved by Black and

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[1] Born at Arezzo in 1519; died at Rome in 1603. His medical works contain some scattered chemical observations, which, however, are of little importance.

[2] Libavius has sometimes been cited as the most rational chemical inquirer of his age, but of this character I can find no justification in his writings upon chemical subjects; they are either unintelligible, or trifling; he certainly had some merit as a contriver of apparatus, and his furnaces and distillatory vessels appear to have been ingeniously devised.

He died in 1616.

[3] "Nempe animalculum quodvis una cum lucernâ in vitro includatur, ita ut aeri externo aditus præcludatur, quod facilè factu est. Quo facto lucernam istam brevì expirantem videbimus; neque animalculum diu tedæ ferali superstes erit. Etenim observatione compertum habeo, animal unà cum lucernâ in vitro inclusum, haud multò plus, quam dimidium temporis istius, quo aliàs viveret spiraturum esse." *Tractatus quinque*, cap. vii. He then goes on to show that an animal requires less air than that wanted for the combustion of a candle, and endeavours to prove that the air in which an animal has been suffocated will not support flame. "Verisimile est autem aerem, qui vitæ sustinendæ inidoneus est, etiam ad flammam conflandum ineptum esse. Quoniam ad lucernæ deflagrationem majori particularum aerearum copiâ quam ad vitam sustinendam opus sit. Advertendum est autem hic loci, quod etsi flamma vitaque iisdem particulis sustinentur, non tamen propterea putandum est, sanguinis massam reverâ accensum esse." *Tractatus quinque*, L. c. Mayow's observations on the changes produced by the breathing of animals, on the air, are not less acute than those relating to the phenomena of combustion.

others; and this opinion seemed to be sanctioned by the discovery, that air thus tainted by respiration and combustion, might, in some measure, be restored to purity by exposure to the action of lime water, which absorbed the fixed air.

In 1772, Dr Rutherford, Professor of Botany in the University of Edinburgh, published a thesis on fixed, or, as it was then called, mephitic air, from which the following passage is extracted.[1] "By the respiration of animals, healthy air is not merely rendered mephitic, but also suffers another change. For, after the mephitic portion is absorbed by a caustic alcaline lixivium, the remaining portion is not rendered salubrious, and although it occasions no precipitate in lime water, it nevertheless extinguishes flame, and destroys life."

Thus we have traced the discovery of two gaseous fluids differing from common air: fixed air, discovered by Black, and *azote*, as it has since been called, by Rutherford. The former, a component part of chalk, and of the mild alcalis, the product of the combustion of charcoal, and of the respiration of animals; the latter an ingredient of atmospheric air.

It would be a wearisome and unprofitable occupation to record, even in brief terms, the transactions of a set of cavilling philosophists who started up in this country, and elsewhere, about the present period of our history; their names have sunk into oblivion, and their works were only read while recommended by novelty. Some of them I have reluctantly perused, and have found that they are rather calculated to weary the attention than to satisfy curiosity, or impart information.

I therefore hasten to one of the most remarkable and splendid epochs of chemical science, adorned by discoveries which have been rarely equalled, either in number or importance, and ushered in by a series of sterling facts and memorable investigations. The well known names of Priestley, Scheele, Cavendish, and Lavoisier, now appear upon the stage, and it will be an arduous but gratifying task to follow them through their respective parts. In this recital, a strict adherence to the dates of discoveries would neither be convenient nor useful, and I shall rather therefore deviate a little on this point, than cloud the perspicuity of my narrative, or cramp it by chronological strictness.

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1 "Sed aer salubris et purus, non modo respiratione animali ex parte fit mephiticus sed et aliam indolis suæ mutationem inde patitur. Postquam enim omnis aer mephiticus ex eo, ope lixivii caustici secretus et abductus fuerit, qui tamen restat nullo modo salubrior inde evadit, nam quamvis nullam ex aqua calcis præcipitationem faciet, haud minus quam antea, flammam et vitam extinguit."

Dr Priestley's character was of so composite an order as to defy brief description or superficial delineation ; he was a politician, a divine, a metaphysician, and a philosopher ; and in each of these callings he displayed abilities of a peculiar and occasionally exalted description. His copious and important contributions to chemical science are the more surprising, when it is remembered that his philosophical pursuits were merely resorted to as a relaxation in his theological studies ; that his mind was under the constant agitation of controversy and dispute ; that he was too impatient for deep research, and too hasty for premeditated plans. But, with all these bars against him, he was a thriving wooer of science : he made more of his time than any person of whom I ever read or heard ; and possessed the happy and rare talent of passing from study to amusement, and from amusement to study, without occasioning any retrograde movement in the train and connection of his thoughts.

There is another important feature in Dr Priestley's character, which may tend to throw some light upon his controversy with the French school : He possessed the strictest literary and scientific honesty ; he makes frequent mention of his predecessors and contemporaries, and enumerates the ideas which he borrowed from them, and the experiments they suggested, with more than necessary accuracy and minuteness. His attachment to Chemistry seems to have been formed at Leeds, [1] about the year 1768, and between that period and the year 1772 he had added several new and highly important facts to the science, which are detailed in a long communication presented to the Royal Society in the spring of that year. It is here that he relates those research-

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[1] Dr Priestley was born at Fieldhead, near Leeds, in March 1733. In 1758, he went to Nantwich in Cheshire, where he established a school, and was, for the first time, enabled to purchase some philosophical instruments, in the use of which he instructed his scholars. In 1761, he removed to Warrington, whence he made regular annual visits to the metropolis, and became acquainted with Mr Canton, Dr Franklin, and Dr Watson, who assisted him in collecting materials for his History of Electricity. In 1767, Dr Priestley went to Leeds, where his attention was especially directed to the *doctrine of air*, in consequence of residing near a public brewery, where he amused himself by experiments on the fixed air produced by fermentation. " When I removed from that house," says he (*Memoirs* of his own Life, p. 61), " I was under the necessity of making the fixed air for myself; and one experiment leading to another, as I have distinctly and faithfully noted in my various publications on the subject, I by degrees contrived a convenient apparatus for the purpose, but of the cheapest kind." Dr Priestley's first publication on this subject was in 1772, and related to the impregnation of water with fixed air, and the same year, in the month of March, his *Observations on different kinds of Air*, were read before the Royal Society, to which body he continued to communicate his other valuable researches. In 1794 he embarked for America, and took up his residence in Pennsylvania, where he died on the 6th of February 1804.

We have here omitted all allusions to his religious opinions and controversies, referring our readers to his *Memoirs*, and to his life in the *General Biographical Dictionary*.

es respecting the influence of vegetation upon the atmosphere, which led to entirely new views of the physiology of plants, and which displayed, in a striking light, some of those masterly and beneficent adjustments of nature, by which the different members of the creation are made to minister to each other's wants, and thus preserve that eternal harmony which marks the natural world.

As combustion and respiration were connected with the deterioration of air, it occurred to Dr Priestley to ascertain how far the growth of vegetables might be productive of similar effects.

"One might have imagined," says he, "that since common air is necessary to vegetable as well as to animal life, both plants and animals would affect it in the same manner; and I own I had that expectation when I first put a sprig of mint into a glass jar, standing inverted in a vessel of water; but when it had continued growing there for some months, I found that the air would neither extinguish a candle, nor was it at all inconvenient to a mouse which I put into it."

In experiments of this kind, Dr Priestley points out the necessity of often withdrawing the dead and dying leaves, lest, by their putrefaction, they should injure the air; he also hints at the noxious powers of some plants, especially the cabbage, of which he kept a leaf in a glass of air for one night only, and in the morning a candle would not burn in it. [1]

Dr Priestley also extended his experiments to the influence of plants upon air vitiated by animal respiration and by combustion, and found that they in general did not only not contaminate the air, but that they actually restored to purity that which had been rendered impure by flame and breathing; and by showing that this change was

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[1] At the beginning of the last summer, I confined, in equal portions of atmospheric air, as nearly as possible, equal surfaces of the leaves of spearmint, cabbage, mustard, bean, pea, and the vine. The plants were all thriving, and, during a great part of the day, were exposed to the sun. The bulk of the air, which was confined over water, was not altered either by the mint or vine leaves; the pea and bean leaves caused a slight diminution, but the air, in contact with the cabbage and mustard plant, was lessened by about one-fifteenth and one sixteenth its original bulk, and it extinguished a taper, which the others did not. The duration of each experiment was 48 hours. The average of the thermometer, during the period, was 52°, and of the barometer, 29,5 inches. This is not the place to enter into any explanation of these facts, or to enlarge the account of them; they prove, however, a corroboration of Priestley's assertion, that different vegetables act very differently on the air, and may be useful in adjusting some discordant results of later experimentalists. Some plants are much more gross feeders than others, and the nature of the soil in which they grow may often be, in some degree, judged of by their flavour. Those vegetables which are of very quick and luxuriant growth, and readily susceptible of the influence of manures, affect the atmosphere more than those whose growth is comparatively slow, and whose foliage is sparing.

effected by groundsel as perfectly as by mint, proved it independent of the aromatic oil to which some in their ignorance had been willing to refer it.

That actual vegetation was necessary, and the mere vegetable insufficient, he proved by exposing the pulled leaves of a mint plant to air, which were unproductive of the regeneration effected by the growing sprig.

Dr Priestley concluded from these experiments, that the noxious air resulting from combustion, and from the breathing of the different animal tribes, formed part of the nourishment of plants ; and that the purity of our atmosphere, and its fitness for respiration, were materially dependent upon the functions of growing vegetables.

Mayow in 1674, and Hales in 1724, had observed the production of gaseous matter during the action of nitric acid upon the metals. I have before alluded to the very rude manner in which Mayow collected it. Hales ascertained its singular property of producing red fumes when mixed with common air. Dr Priestley resumed these inquiries, and pursued them with clever activity : he found, that, on mixing one hundred parts, by measure, of common air, with one hundred of the air procured by the action of nitrous acid on copper, which he called nitrous gas, red fumes were produced, and there was a diminution of bulk equal to ninety-two parts in the two hundred ; so that one hundred and eight parts only remained.

When fixed air was thus mixed with nitrous air, there was no diminution ; when air, contaminated by combustion or respiration, was used, the diminution was less than with purer air ; and with air taken from different situations, Dr Priestley thought he obtained rather variable results. Hence the beautiful application of nitrous air to the discovery of the fitness of other species of air, for combustion and respiration.

It was for these discoveries that the Council of the Royal Society honoured Dr Priestley by the presentation of Sir Godfrey Copley's medal, on the 30th of November 1733. [1] 1773

* " Sir Godfrey Copley originally bequeathed five guineas to be given at each anniversary meeting of the Royal Society, by the determination of the president and council, to the person who had been the author of the best paper of experimental observation for the year past. In process of time, this pecuniary reward, which could never be an important consideration to a man of enlarged and philosophical mind, however narrow his circumstances might be, was changed into the more liberal form of a gold medal, in which form it is become a truly honourable mark of distinction, and a just and laudable object of ambition. It was, no doubt, always usual with the Presidents, on the delivery of the medal, to pay some compliment to the gentleman on whom it was bestowed, but the custom of making a set speech on the occasion, and of entering into the history of that part of philosophy to which the experiment related, was first introduced by

Sir John Pringle, who was then President, delivered, on this occasion, an elaborate and elegant discourse upon the different kinds of air, in which, after expatiating upon the discoveries of his predecessors, he points out the especial merits of Priestley's investigations: In allusion to the purification of a tainted atmosphere by the growth of plants, the President has thus expressed himself:

"From these discoveries we are assured, that no vegetable grows in vain; but that, from the oak of the forest to the grass of the field, every individual plant is serviceable to mankind; if not always distinguished by some private virtue, yet making a part of the whole which cleanses and purifies our atmosphere. In this the fragrant rose and deadly nightshade co-operate; nor is the herbage nor the woods that flourish in the most remote and unpeopled regions unprofitable to us, nor we to them, considering how constantly the winds convey to them our vitiated air, for our relief and for their nourishment. And if ever these salutary gales rise to storms and hurricanes, let us still trace and revere the ways of a beneficent Being, who not fortuitously, but with design, not in wrath, but in mercy, thus shakes the water and the air together, to bury in the deep those putrid and pestilential effluvia which the vegetables on the face of the earth had been insufficient to consume." [1]

Mr Martin Folkes. The discourses, however, which he and his successors delivered, were very short, and were only inserted in the minute books of the Society; none of them had ever been printed before Sir John Pringle was raised to the chair of the Society." Chalmers's *Biographical Dictionary.—Life of Pringle.*

Dr Franklin, in a letter upon the subject of this discovery to Dr Priestley, has expressed himself as follows:

"That the vegetable creation should restore the air which is spoiled by the animal part of it, looks like a rational system, and seems to be of a piece with the rest. Thus, fire purifies water all the world over. It purifies it by distillation when it raises it in vapours, and lets it fall in rain; and farther still by filtration, when, keeping it fluid, it suffers that rain to percolate the earth. We knew before that putrid animal substances were converted into sweet vegetables when mixed with the earth and applied as manure; and now, it seems that the same putrid substances, mixed with the air, have a similar effect. The strong thriving state of your mint, in putrid air, seems to show that the air is mended by taking something from it, and not by adding to it. I hope this will give some check to the rage of destroying trees that grow near houses, which has accompanied our late improvements in gardening, from an opinion of their being unwholesome. I am certain, from long observation, that there is nothing unhealthy in the air of woods; for we Americans have everywhere our country habitations in the midst of woods, and no people on earth enjoy better health, or are more prolific." *Phil. Trans.* 1772, page 199.

Notwithstanding these researches, which have exposed some very curious facts relative to the chemical physiology of plants, it must be confessed that the causes of the renovation and equality of our atmosphere are yet by no means ascertained; for, although some growing vegetables do, under certain circumstances, purify the air (by the absorption of carbon and the evolution of oxygen), yet, when in a state of decay, they invariably add to its contamination, and a general view of the subject would induce us to conclude,

Such were Dr Priestley's researches, and such the views to which he had been led previous to the year 1773, when he undertook the examination of the air which rises from red lead, and from red precipitate of quicksilver, when those substances are exposed to heat. This, indeed, was one of the topics upon which Hales had touched before him, but it was passed over with that hasty and superficial carelessness of which his experimental proceedings furnish so many instances, and in which he so often lost the substance by grasping at the shadow.

Dr Priestley cast his keenest eye upon the prospect now before him, and as the various objects came into view, he followed them up with more than his ordinary diligence and usual sagacity. The track he had entered upon was, indeed, of such abundant promise, as would have insnared the attention and excited the curiosity of one less awake than our author to its interest and novelty. But he, already well initiated in the management of aëriform fluids, proceeded with a rapidity which left his associates far behind, and carried him, in proud and undisputed precedence, to the goal of discovery.

The 1st of August 1774 is a *red-letter day* in the annals of Chemical Philosophy, for it was then that Dr Priestley discovered dephlogisticated air. Some, sporting in the sunshine of rhetoric, have called this the birth-day of Pneumatic Chemistry; but it was even a more marked and memorable period; it was then (to pursue the metaphor) that this branch of the science, having eked out a sickly and infirm infancy in the ill-managed nursery of the early Chemists, began to display symptoms of an improving constitution, and to exhibit the most hopeful and unexpected marks of future importance.

Dr Priestley's original opinion, that all kinds of factitious air were noxious, seems first to have been shaken by observing that a candle would burn in air procured by distilling nitre in a gun barrel; but the first experiment, which led to a very satisfac-

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that they do as much harm as good, at least, if recent experiments connected with this subject are to be considered as correct.

These are the prominent features of Dr Priestley's first communication to the Royal Society respecting the different kinds of air, and had he bestowed no other contribution upon chemistry, the facts here detailed would have entitled him to a conspicuous place among the benefactors of the science. The paper is divided into several sections, in which he discusses the nature and properties of fixed air; of the air contaminated by the combustion of candles and of brimstone; of inflammable air; of air infected with animal respiration or putrefaction; of air exposed to the action of mixtures of iron filings and sulphur; of nitrous air; of air in which metals have been calcined, and which has been exposed to the action of white-lead paint; and of air procured by spirit of salt.

tory result, was conducted as follows. A glass jar was filled with quicksilver, and inverted in a basin of the same; some *red precipitate of quicksilver* was then introduced, and floated upon the quicksilver in the jar; heat was applied to it in this situation by a burning lens, and "I presently found that air was expelled from it very readily. Having got about three or four times as much as the bulk of my materials, I admitted water into it, and found that it was not imbibed by it. But what surprised me more than I can well express, was, that a candle burned in this air with a remarkably vigorous flame, very much like that enlarged flame with which a candle burns in nitrous air exposed to iron or liver of sulphur; but, as I had got nothing like this remarkable appearance from any kind of air besides this peculiar modification of nitrous air, and I knew no nitrous acid was used in the preparation of *mercurius calcinatus*, I was utterly at a loss how to account for it."[1]

He afterwards obtained the same kind of air by exposing red lead and several other substances to heat, and made a number of well-devised experiments upon its properties.

Those who, for the first time, witness the effect of this air upon burning bodies, will best picture to themselves the emotion and surprise of its discoverer, when he plunged a burning taper into it. The splendour of the flame was magnificently increased, the consumption of the wax was extremely rapid, and the heat evolved much more considerable than in common air. He found, in short, that, in all cases of combustion, the process was infinitely more rapid and perfect in this kind of air, than in the ordinary atmosphere;[2] and he was thence induced to apply the term *dephlogisticated* to the gas he had thus obtained. He regarded it as air deprived of phlogiston, and thus accounted for its eager attraction for that principle which, during combustion, bodies were imagined to throw off. On the contrary, he accounted for

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[1] *Experiments and Observations on Different Kinds of Air*, &c. Vol. II. p. 107. *Birmingham*, 1790.

[2] The following paragraph, with which Dr Priestley prefaces his account of the discovery of dephlogisticated air, presents a picture of his mind in regard to the origin of his own researches.

"The contents of this section will furnish a very striking illustration of the truth of a remark which I have more than once made in my philosophical writings, and which can hardly be too often repeated, as it tends greatly to encourage philosophical investigations; viz. that more is owing to what we call *chance*, that is, philosophically speaking, to the observation of *events arising from unknown causes*, than to any proper design or preconceived *theory* in this business. This does not appear in the works of those who write *synthetically* upon these subjects, but would, I doubt not, appear very strikingly in those who are the most celebrated for their philosophical acumen, did they write *analytically* and ingenuously." (*Exp. and Obs.* Vol. II. p. 103.)

the extinction of flame by the air discovered by Rutherford, and since termed azote [1] or nitrogen, [2] upon the idea that that aeriform fluid was charged or saturated with phlogiston, and he therefore called it phlogisticated air. [3]

In enumerating the higher merits of Dr Priestley as a discoverer, we must not forget the minor advantages which his ingenuity bestowed upon experimental Chemistry. He supplied the Laboratory with many new and useful articles of apparatus, and the improved methods of managing, collecting, and examining gaseous fluids, were chiefly the results of his experience. He was the first who, with any chance of accuracy, endeavoured to ascertain the relative or specific gravities of the different kinds of air then known; he observed that dephlogisticated air was rather heavier, and phlogisticated air somewhat lighter, than that of the atmosphere; nitrous air he conceived to be nearly of the same specific gravity. His experiments were made by the help of a delicate balance and exhausted flask.

The influence upon the respiration of animals of a species of air marked by the eminent perfection with which it supports combustion, did not escape Dr Priestley's notice. On applying to it his test of nitrous air, he found the absorption produced on mixture greater than with atmospheric air; whence he conjectured its superior fitness for the support of life; he introduced mice into it, and found that they lived longer than in an equal bulk of atmospheric air; he then had the curiosity to taste the gas himself, and after two or three respirations, he felt, or fancied he felt, a peculiar sensation of lightness and ease of the chest. " Who can tell," says he, " but that in time this pure air may become a fashionable article in luxury.—Hitherto only two mice and myself have had the privilege of breathing it." To this he foolishly adds, that " the air which nature has provided for us is as good as we deserve."

We have not yet exhausted Dr Priestley's discoveries, but have seen enough to establish his claims to the title of a great benefactor to chemical science. If we compare him with his predecessor Black, he falls short in depth of judgment, but in quickness of conception, and industry of pursuit, he excels even such a standard of comparison. The one climbed the hill of discovery with slow and cautious steps, and

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[1] From *α* and *ζωη*, " destructive of life."

[2] *i.e.* Producer of nitric acid.

[3] The application of dephlogisticated air to obtain intense degrees of heat, and its probable uses in medicine, were subjects which did not altogether escape Dr Priestley's attention, and he has alluded to them in the section of the work already quoted, relating to its " Properties and Uses."

calmly enjoyed the surrounding views; the other made a more rapid ascent, but was giddy when he reached the summit; hence those distortions and misconceptions, those erroneous notions and hasty conclusions which he who turns over the philosophical writings of Dr Priestley cannot fail to discern.

Upon the other productions of his pen, metaphysical, political, and moral, it is neither my province nor inclination to dwell; they abound in the defects, but are deficient in the merits, of his tracts upon chemical subjects.

From the commencement to the termination of his busy career, Dr Priestley was a staunch supporter of the unintelligible system of phlogiston; he adopted it in all its original incoherence and absurdity; and the last of his scientific publications was a tract in its defence, in which are adduced a variety of objections to the revived hypotheses of Rey and Mayow, and Hooke, which having long lain dormant, were at this time erupted into the chemical world under the specious title of the French theory.[1]

It will not be denied that the leading facts just detailed threw considerable light upon the nature and properties of atmospheric air; but those who have entitled Dr Priestley the discoverer of its composition, have somewhat overstepped the bounds of correctness.

He seems, indeed, to have possessed no just notions of the difference between phlogisticated and dephlogisticated air; and, instead of regarding them as distinct chemi-

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[1] The tract alluded to in the text was published by Dr Priestley after his retirement to America in 1800. It is entitled, *The Doctrine of Phlogiston established, and that of the Composition of Water refuted.* It contains a variety of miscellaneous observations on the phlogistic and antiphlogistic theories, but it would be useless to follow the author into his unsubstantial speculations on these subjects. He has, however, thrown out some important considerations relating to his claims of originality as the discoverer of dephlogisticated air. The following paragraph appears of sufficient importance to be transcribed. "Now that I am on the subject of the *right to discoveries,* I will, as the Spaniards say, leave no ink of this kind in my inkhorn; hoping it will be the last time that I shall have any occasion to trouble the public about it." M. Lavoisier says (*Elements of Chemistry, English translation,* p. 36), "this species of air (meaning dephlogisticated) was discovered almost at the same time by Mr Priestley, Mr Scheele, and myself." The case was this:—Having made the discovery some time before I was in Paris in 1774, I mentioned it at the table of M. Lavoisier, when most of the philosophical people in the city were present; saying, that it was a kind of air in which a candle burned much better than in common air, but I had not then given it any name. At this all the company, and M. and Madame Lavoisier as much as any, expressed great surprise; I told them I had gotten it from *precipitate per se,* and also from *red lead.* Speaking French very imperfectly, and being little acquainted with the terms of chemistry, I said *plomb rouge,* which was not understood, till M. Macquer said, I must mean *minium.* Mr Scheele's discovery was certainly independent of mine, though I believe not made quite so early." P. 88.

cal principles, adopted the notion of one elementary substance, charged, in the one instance, with the imaginary essence of inflammability, and free from it in the other. In these inquiries, he frequently verges upon more correct and refined views, but has no sooner entered the right path, than phlogiston, like an *ignis fatuus,* dances before his eyes, and leads him into the marshy mazes of error.

In the preceding investigations, Dr Priestley followed those methods of collecting aeriform fluids over water, which Hales and others had employed before him: he now ascertained that there were some gases absorbed by or soluble in water. Mr Cavendish, one of the most eminent Philosophers of that day, had announced this circumstance, and was puzzled by it; but Dr Priestley, with his usual and dexterous ingenuity, overcame the difficulty, by employing quicksilver instead of water, over which fluid metal he preserved and examined several kinds of air, which are instantly deprived of their elastic state by the contact of water.

The first permanently elastic fluid of this description which he examined, was the muriatic acid; he obtained it by heating copper in the fluid acid, or common spirit of salt, and called it marine acid air.

He immediately ascertained its absorption by water, and its powerful acidity; he found it incapable of supporting flame, and extremely destructive of animal life. He examined the action of a variety of substances upon this gas, and ascertained the remarkable rapidity with which it is absorbed by charcoal, and several vegetable and animal substances. Some unsuccessful attempts were made to ascertain the specific gravity of this gas, from which Dr Priestley correctly concluded, however, that it was a little heavier than air.

The success attending these experiments, and the readiness with which he procured and retained the gaseous muriatic acid, led him to extend his trials to other acids, when he found, that, by acting upon vitriolic acid by inflammable substances, he could procure from it a permanently elastic fluid, to which he gave the name of vitriolic acid air; he found that, like the marine acid air, it was rapidly absorbed by water, and must be collected and preserved over quicksilver; that it was nearly twice as heavy as atmospheric air; that it extinguished flame, and was instantly fatal to animal life; that it reddened vegetable blues, and destroyed most colours This air is, in fact, produced by burning sulphur in the atmosphere, and straw, wool, and other materials, are frequently bleached by exposing them to its fumes. [1]

[1] Having elsewhere praised Dr Priestley's candour, I insert the following extract from his history of the

Having thus obtained permanent aeriform fluids, having acid qualities, it occurred to Dr Priestley, that the volatile alcali, the substance which gives pungency to salvolatile, spirit of hartshorn, and similar compounds, might be also procured in a pure and isolated gaseous form; and, after several unsuccessful trials, he succeeded, by heating a mixture of quicklime and sal ammoniac, when a great quantity of air escaped, permanent over quicksilver, but, like the acid gases, rapidly absorbed by water.

The odour of this gas was pungent in the extreme, and it possessed the property of salvolatile, smelling salts, and similar substances, of turning vegetable blues to green. After several experiments, in which the absorbing powers of different substances in regard to this air, were tried, Dr Priestley became impatient to discover the effect of mixing it with the acid airs just described,—he imagined that he should form a neutral air. On putting this notion, however, to the proof of experiment, he was surprised to observe that when marine acid air, and the volatile alcaline air, were mixed in due proportions, they were wholly condensed into a solid. And with sulphureous air a very similar result was afforded.

Dr Priestley concluded that alcaline air was considerably lighter than acid air, because, on mixing them over mercury, he observed the former to float above the latter;

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discovery of *Vitriolic Acid Air*, to show the exactness with which he acknowledges the hints and assistance of others:

"My first scheme was to endeavour to get the vitriolic acid in the form of air, thinking that it would probably be easy to confine it by quicksilver, for, as to the nitrous acid, its affinity with quicksilver is so great that I despaired of being able to confine it to any purpose. I, therefore, wrote to my friend Mr Lane to procure me a quantity of volatile vitriolic acid," &c. "Seeing Mr Lane the winter following, he told me, that if I would only heat any oily or greasy matter with oil of vitriol, I should certainly make it the very thing I wanted, viz. the volatile or sulphureous vitriolic acid; and, accordingly, I meant to have proceeded upon this hint, but was prevented from pursuing it by a variety of engagements.

"Some time after this I was in company with Lord Shelburne, at the seat of Mons. Trudaine, at Montigny, in France; where, with that generous and liberal spirit by which that nobleman is distinguished, he has a complete apparatus of philosophical instruments, with every other convenience and assistance for pursuing such philosophical inquiries as any of his numerous guests shall chuse to entertain themselves with. In this agreeable retreat I met with that eminent philosopher and chemist, Mons. Montigni, Member of the Royal Academy of Sciences; and conversing with him upon this subject, he proposed our trying to convert oil of vitriol into vapour, by boiling it on a pan of charcoal in a cracked phial. This scheme not answering our purpose, he next proposed heating it together with oil of turpentine. Accordingly, we went to work upon it, and soon produced some kind of air confined with quicksilver; but our recipient being overturned by the suddenness of the production of the air, we were not able to catch any more than the first produce, which was little else than the common air which had lodged on the surface of the liquor, and which appeared to be a little phlogisticated by its not being much affected by a mixture of nitrous air."

on putting a lighted candle into alcaline air the flame was enlarged, and a portion of the air appeared to burn with flame.

We have now considered the principal discoveries of Dr Priestley, upon which his title to originality rests, and it must be allowed that they are not less important than numerous. If we even consider them merely as insulated facts, they are of a very superior character, and tended greatly to enlarge our knowledge of the chemical elements of matter; but the new views of many natural and artificial phenomena, which they exposed, and which before were buried in deep obscurity, confer upon them a more exalted aspect, and have obtained for them the deserved meed of universal admiration. In perusing Dr Priestley's tracts, we find the thread of the narrative occasionally knotted with conceit, and weakened by garrulity; but these blemishes are compensated by prevailing candour and perspicuity of style: he had greatly extended the boundaries of science, and was awake to the importance of his conquests; but resisted that febrile thirst of innovation and reform, which was endemic among contemporary Chemists.

"At present," says he, in the Preface to his third volume of *Experiments and Observations*, relating to various branches of Natural Philosophy, "At present all our *systems* are in a remarkable manner unhinged by the discovery of a multiplicity of *facts*, to which it appears difficult or impossible to adjust them: We need not, however, give ourselves much concern on this account. For when a sufficient number of new facts shall be discovered, towards which even imperfect hypotheses will contribute, a more general theory will soon present itself, and perhaps to the most incurious and least sagacious eye. Thus, when able navigators have, with great labour and judgment, steered towards an undiscovered country, a common sailor, placed at the mast head, may happen to get the first sight of land. Let us not, however, contend about merit, but let us all be intent on forwarding the common enterprise, and equally enjoy any progress we may make towards succeeding in it, and, above all, let us acknowledge the guidance of that great Being, who has put a spirit in man, and whose inspiration giveth him understanding." With this quotation, sufficiently characteristic of his general style, I shall take leave of Dr Priestley, and introduce another hero of chemical history, his contemporary and great rival, Scheele.

SECTION V.

DISCOVERIES OF SCHEELE AND CAVENDISH.

Among those whose names became eminent in the history of chemical science during the first half of the eighteenth century, Margraaf and Bergman are entitled to particular mention. The former was a pupil of the once celebrated Neumann, [1] a man whose works are now not much thought of, but who did considerable service to the Chemistry of his day, and was evidently possessed of great diligence and some capacity. In 1733, Margraaf [2] pursued chemistry under Juncker at Halle, and, having returned to Berlin in 1738, we find several of his contributions in the *Transactions of the Scientific Society* of that capital. Subsequent to that period, his works were collected and published at Paris in 1762. They contain a great body of information, at that time novel and important, but they are chiefly entitled to notice as furnishing specimens of the art of analysis, which was afterwards carried to greater perfection by Bergman, [3] who, indeed, may be considered as the first who pointed out the true objects of that branch of the science, and who aimed at conferring upon it the statical accuracy which has since rendered it so important and useful.

But Bergman was something more than a diligent experimentalist and acute reasoner; he was also an active patron of science, and had the merit of rescuing Scheele

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[1] Casper Neumann was born at Zullichau in Prussia, in 1682, and in 1705 we find him enjoying the patronage of the King of Prussia, by whom he was sent to complete his studies at the University of Halle. In 1711 he became a pupil of Boerhaave, and shortly after visited England, whence he accompanied George I. to Hanover in 1716. In 1723 he became Professor of Practical Chemistry in the Royal College of Berlin, where he died in 1737. His works consist chiefly in dissertations on various subjects of chemical inquiry, published in the *Transactions of the Royal Society*, and in the *Miscellanea Berolinensia*. His Lectures were not printed till after his death, and proved a valuable magazine of chemical knowledge. " The author," says Dr Lewis, who edited his works, " biassed by no theory, and attached to no opinions, has inquired by experiment into the proportions and uses of the most considerable natural and artificial productions, and the preparations of the principal commodities which depend on chemistry, and seems to have candidly and without reserve communicated all he discovered."

[2] Born at Berlin in 1709, where he died in 1782.

[3] Torbern Bergman was born in Sweden in 1735, and died in 1784. His principal chemical papers are contained in the *Opuscula*, published at Upsal in 1779. They contain much to admire, not merely as being rich in facts and discoveries, but also on account of the general views which he takes of the mode of prosecuting philosophical inquiry, and which is so ably set forth in the preliminary essay, *De Indagando Vero*. The *Opuscula* was translated into English by Dr Edmund Cullen in 1788.

from his obscure situation, and of discerning that talent and genius in the bud which afterwards was so vigorously fruitful.

If we compare Scheele with our own countrymen, we discern him possessed of the accuracy and cool judgment of Black, conjoined with the inquisitive and busy activity of Priestley, and his success in the pursuit of science was such as might be expected to flow from this happy and rare union of opposite talents. In the number of his discoveries, their weight, and novelty, he has indeed very few equals; nor has their splendour been tarnished by time, or dimmed by the brilliant light of modern investigation.

Scheele is among the fortunate few, who, starting from an obscure original, have attained the zenith of scientific eminence. He was born in 1742 at Stralsund, where his father was a tradesman. His youthful days were passed in the house of an Apothecary at Gottenburgh, where, by singular perseverance, and that kind of industry which is prompted by strong natural inclination, he acquired a valuable stock of chemical information. In 1773, having removed to Upsal, accident brought him acquainted with Bergman, who became his friend and patron, and to whose honour be it told, that, when Scheele's reputation afterwards rose to such a height as threatened to eclipse his own, instead of listening to the voice of jealousy, which, on such occasions, is too common a frailty, he became more zealous in behalf of his rival, and more indefatigable in the service of his friend. Scheele afterwards removed to Köping, in the neighbourhood of Stockholm, where he died in 1786.

No adventitious aid, however, can be said to have contributed to Scheele's greatness. On the contrary, obstacles were opposed to his progress which would have damped the ardour, and checked the flight, of less aspiring and persevering minds; and much of his useful life was spent, " not in the soft obscurities of retirement, or under the shelter of academic bowers, but amid inconvenience and distraction, in sickness and in sorrow."

Scheele's first publication, which appeared in the *Stockholm Memoirs* [1] for the year 1771, relates to the analysis of fluor spar. The peculiarities of this substance were first noticed in 1768 by Margraaf, but the discovery of the principle upon which they depend was reserved for the superior sagacity of Scheele, who demonstrated in it the existence of lime, and an acid till then unknown, which he called fluoric acid.

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[1] Scheele's *Essays* have been collected and translated into English by Dr Thomas Beddoes. London, 1786.

Scheele had applied acid of vitriol with great success to the analysis of a variety of substances, and on exposing powdered fluor spar to its action in a glass retort, he obtained the new body in question. The fluoric is one of the few acids which rapidly corrode glass; it dissolves silicious earth, a component part of glass, and forms with it an aëriform compound, permanent until it touches water, when part of the silicious earth is deposited. Scheele, not aware of this fact, at first conceived that silicious earth was a compound of fluoric acid and water, for, on evolving the gas in a glass retort, and allowing it to pass into water, every bubble was coated with a film of flint; but he afterwards learned, that it was derived from the retort, which is soon eaten into holes. It is this property of fluoric acid which has led to its employment for the purpose of etching upon glass.

Scheele was next occupied in a series of researches on manganese, a mineral substance abundant in many parts of the world, but of which the nature was unknown until the appearance of his *Dissertation* upon it in 1774. This tract is full of important facts, and glitters with brilliant discoveries. We are here first informed that manganese is a metallic calx; that in its crude state it often contains a peculiar earth, to which the name *barytes* has since been applied; that the volatile alkali contains nitrogen as one of its essential component parts. But the most remarkable novelty announced in this Essay, is the discovery of a peculiar gaseous fluid of a yellow colour, which Scheele considered as the basis of the muriatic acid, conceiving the addition of phlogiston requisite to the restoration of its acid properties. This *dephlogisticated marine acid*, as its discoverer termed it, was examined by him with some precision, and many of its leading characters ascertained, especially its power of destroying colour, which has since rendered it of so much importance to the bleacher. It has since been termed *oxymuriatic acid*, and more recently *chlorine*. Besides the valuable facts to which I have now alluded, Scheele's *Essay on Manganese* contains others of considerable interest and importance. There can be little doubt that he discovered azote about the same time as Dr Rutherford. He obtained it by exposing compounds of sulphur, and the alcalies and earths, to confined portions of atmospheric air. He found a part was absorbed, and that the remainder, though not fixed air, was still incapable of supporting combustion. He went a step farther, and demonstrated the existence of azote in the volatile alcali or ammonia, from which he obtained it by the action of certain compounds of manganese.

For our knowledge of the method of obtaining tartaric and citric acids in their pure

state from tartar and lemon juice, we are also indebted to Scheele, and for a variety of curious and interesting documents relating to some of the metallic acids, and their combinations. A compound of one of the acids of arsenic and copper was particularly described by him, and recommended as a green pigment; he prepared it by adding to a solution of blue vitriol, an alcaline solution of white arsenic.

His chemical tracts on the nature and properties of milk, his observations on ether, on the preservation of vinegar, on Prussian blue, and on the nature of the acid matter in various fruits, are all entitled to the highest praise. A just notion of their excellence may be formed by comparing them with the essays of the ablest Chemists of the present day: in regard to experimental accuracy and just conclusion, they generally stand this severe test; no small merit, when his humble means and deficient education are thrown into the balance against him.

But, of the various works of Scheele, that which is most decidedly characteristic of an inventive and original genius, is his *Chemical Observations and Experiments on Air and Fire.* Every page of this treatise has its merits, and they are distinct and peculiar; sometimes we are struck with the sagacity of his inductions, at others, with the appropriateness of his experiments. The facts are detailed in intelligible, clear, and distinct arrangement; the theoretical speculations are adduced with that caution and modesty which ensures attention, and often commands acquiescence. Nor is this essay deficient in original discoveries of the highest class. He obtained oxygen from manganese without any knowledge of Priestley's prior claims; he calls it *empyreal air*, and has detailed its properties and several modes of procuring it, with becoming accuracy and minuteness. Upon the composition of the atmosphere, and of metallic calces, he dwells at considerable length, and relates several remarkable facts concerning the chemical powers of the prismatic rays, and the radiation of terrestrial heat. [1]

From one who wrote in that twilight period, when chemical philosophy was emerging from error and absurdity, we are not to expect the logical accuracy required at the present day. Scheele is sometimes hasty, and occasionally unintelligible; but seldom careless, and never ridiculous. Different men will form different estimates of Scheele's talents, and although I cannot agree with a contemporary biographer who designates

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[1] In this admirable Dissertation, Scheele points out the difference between the heat which radiates from a heated surface, and that which is diffused by currents of hot air. He also shows, that terrestrial radiant heat does not pass through glass, while that of the sun does; that polished glass and metal reflect both heat and light, but that both are absorbed by a surface covered with lamp black; and that the direction of radiant heat is not diverted by a current of air.

him "as the brightest ornament of human nature, and the most extraordinary man that ever existed;" it will, I think, be generally admitted, that he was an acute and industrious philosopher, and an upright honourable man.

Of the Chemical Philosophers that adorned the last age, the Honourable Henry Cavendish[1] stands foremost in the first rank.

While Priestley and Scheele were extending the boundaries of knowledge, and pursuing that brilliant career of which I have just presented an outline, Cavendish was not less successfully employed in another train of investigation.

Van Helmont, Mayow, and Hales, had, by a series of crude and imperfect experiments, demonstrated the existence of inflammable aeriform fluids; but the nature of the peculiar principle to which they owe their inflammability had been but very imperfectly ascertained till Cavendish turned his mind to the subject, and published upon it in the *Philosophical Transactions for* 1776. The paper I allude to consists of three tracts, relating to inflammable, fixed, and nitrous air. The first is chiefly entitled to attention from its originality and importance; in the others he had been anticipated by Mayow and Black, or excelled by Priestley, Scheele, and others of his contemporaries.

By acting with dilute acids upon iron, zinc, and tin, Mr Cavendish obtained an inflammable elastic fluid. He found that it was afforded in the largest quantity by zinc, and that iron yielded more than tin; and he particularly mentions that the state of dilution, and quantity of the acid, provided it was sufficient to effect the solution of the metal, did not affect the quantity or quality of the air. He discovered in the gas thus obtained several characters, which at once distinguished it from the other varieties of air then known. It was not absorbable by water, it extinguished flame, and was fatal to animal life; but, when a candle was presented to it, it inflamed; and, when pure, burned with a blue lambent light. It was found to be the lightest known form of ponderable matter. Mr Cavendish considered it as about eleven times lighter than atmospheric air; but subsequent experiments have shown that, when it is rendered perfectly dry, and collected in a state of purity, it is about thirteen times lighter than atmospheric air. Compared with oxygen or dephlogisticated air, its relative weight is as 1 to 15.[2]

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[1] Born in London on the 10th of October 1731.

[2] This circumstance has led to its application for filling air balloons, which formerly were made to ascend by distension with rarefied air—a large quantity of fuel became thus necessary, which was greatly incon-

He next proceeded to examine the results afforded by burning mixtures of inflammable and common air; and found that, in the proportion of one part of the former to about three of the latter, the mixture exploded on the contact of flame, and that, when the vessel in which this inflammation was performed was previously dry, it always became moist after the explosion.

This circumstance was noticed by Macquer in 1766, and shortly after by Priestley, but that *water* was the result of the combustion, seems first to have occurred to Mr Watt, who suggested the idea to Dr Priestley in 1783.

In January 1784, Mr Cavendish presented a paper to the Royal Society, entitled *Experiments on Air*, in which, after some preliminary remarks, he adverts to Mr Warltires' experiments, related by Dr Priestley, upon the formation of dew during the combustion of inflammable with common air, which by that gentleman was referred to the deposition of the air's moisture during its phlogistication; for by the Chemists of that period, inflammable air seems to have been considered identical with phlogiston.

The method in which Mr Cavendish pursued this inquiry was not less new than satisfactory, and the body of evidence adduced, so conclusive as to convince the most sceptical mind of the accuracy of his deductions.

To ascertain the nature of the products of the combustion of inflammable air, he had recourse to two plans: he burned it slowly and rapidly,—in the one instance, a stream of the air issuing from a small tube, was inflamed in contact with the atmosphere, or oxygen; in the other, the two gases were mixed, and suddenly detonated; and he found that, proper precautions having been taken to exclude extraneous bodies, the result was perfectly pure water; "it had no taste nor smell, and left no sensible sediment when evaporated to dryness, neither did it yield any pungent smell during the evaporation; in short, it seemed pure water."[1] His grand discovery of the composition of water necessarily led to a variety of others, scarcely inferior in im-

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venient on account of its weight; and the flame required for the rarefaction of the air inclosed in the balloon, was dangerous in the extreme—by confining inflammable air in a silk bag, of sufficient dimensions, its small specific gravity enables it to float in our atmosphere. The first ascent, with a balloon filled with hydrogen, was performed in France by M. Charles, on the 1st of December 1783—he rose to the enormous height of 10,500 feet above the earth's surface. There is a passage in Dewynt's *Sermons*, published in 1658, from which it has been concluded, that balloons were known at that early period.

[1] *Philos. Trans.* 1784. p. 129. Inflammable air has since received the name *hydrogen*, i. e. generator of water.

portance, and it tended to the elucidation of a variety of intricate phenomena in nature and art, in which that universal fluid is concerned. It was verified and established by the analytic and synthetic researches of many modern Chemists, and it became a great organ in subverting the phlogistic doctrine.

In the synthetic experiments proving the composition of water, originally devised and executed by Cavendish, he frequently observed the production of acid matter; the water formed was sour to the taste, and reddened vegetable blues; and he ascertained that these effects arose from the presence of a portion of nitrous acid. Whence this was derived remained to be proved,—whether the elements which, in one proportion, formed water, produced, in another proportion, the nitric acid, or whether it resulted from other causes. In a paper read before the Royal Society, in June 1785, Mr Cavendish sets this curious and interesting question at rest, and developes the source of the acid which appeared in his former investigations. It arose from the presence of a portion of azote which, when made to unite with oxygen, produced nitric acid. The atmosphere has already been shown to consist of azote and oxygen,—these gases are there merely mechanically mixed; when they are made to combine in the presence of water, nitric acid results.

This curious fact was proved by several experiments. That which is most simple, and most satisfactory, consisted in confining a small portion of atmospheric air in a bent tube over quicksilver, and passing the electric spark for some hours through the mixture. A diminution took place in its bulk, the mercury was corroded, and, on introducing a solution of potash, it became saturated, and yielded nitre on evaporation, a salt composed of potash and nitric acid.

These are the principal discoveries with which Cavendish enriched the science of Chemistry; they relate to the properties of hydrogen or inflammable air, to the composition of water, and to the constitution of the nitric acid. They are detailed in three communications to the Royal Society; the first stands in the *Philosophical Transactions* for 1766; the other two in the volumes for 1784 and 1785.

Those who have heard Mr Cavendish designated the Newton of Chemistry, and have only hastily perused his tracts, or witnessed imperfect illustrations of his researches, may perhaps regard him less worthy that honourable and high distinction than his contemporaries Priestley and Scheele; but a more careful examination of his writings, and a comparison of his reasoning and methods of research with those of even his most eminent fellow-labourers in science, will unanswerably support his claims, and display such peculiar and varied excellence, as must justify the highest

encomiums and most elaborate eulogies which have been bestowed on his exalted name. In his philosophical proceedings, the severest scrutineer is challenged to detect a single false step, for every conclusion he has formed, every theory that he has advanced, even every sentence he has written, will bear microscopic examination. Aware that there was no royal road to philosophic truth, he relied solely upon the light of experiment, in the path of induction, and from this he never deviates. If he excelled not his contemporaries in the number of his discoveries, he certainly equalled them in their importance, and went far before them in statical accuracy and mathematical precision : but as a Philosopher he scarcely admits of comparison ; in him most of the defects of his contemporaries were absent, and their talents concentrated ; he was " himself alone." In Cavendish science may boast of a follower not less disinterested than successful : his affluence was princely, and his family noble ; it was therefore not the desire of distinction in society, nor the more imperious call of necessity, but the thirst for knowledge, and love of truth, that summoned him to her banners.

Mr Cavendish did not lisp in the language of science ; it was, indeed, late before he appeared as a candidate for philosophic fame. His first paper was published in the *Transactions of the Royal Society* for 1766, when he was in his 36th year, a period of life at which Black, Priestley, and Scheele, had already acquired no inconsiderable celebrity. He was not confined to Chemistry only ; Electricity and subjects connected with Meteorology and Astronomy often occupied his thoughts and employed his pen : his last essay is on the division of astronomical instruments, published in the *Philosophical Transactions* for 1809. He was then in his 78th year, and in full possession of bodily activity and mental energy. After a few days illness, he expired on the 4th of February 1810, in the 79th year of his age.

In private life, he was unambitious, unassuming, bashful, and reserved : he was peevishly impatient of the inconveniences of eminence ; he detested flattery, and was uneasy under merited praise ; he, therefore, shunned general society, and was only familiar in a very limited circle of friends. Here he bore his great faculties always meekly : his conversation was lively, varied, and instructive ; upon all subjects of science he was at once luminous and profound ; and in discussion, wonderfully acute.

We are now about to enter upon that period of our history at which the science was reformed and modified by the French school. Of this chemical revolution I shall endeavour to present a faithful though faint outline. I shall attempt to show the grounds of innovation, to expose the weak parts of the plan, to exhibit its merits, and to com-

pare it with former theories. In the meantime, it may not be improper to take a rapid survey of the ground we have gone over, and to enumerate the materials already in the hands of the reformers.

In the early hypotheses respecting the phenomena of combustion, they were conceived to depend upon the separation of a peculiar principle, called by Stahl and his associates phlogiston; but the fallacy of these views was shown by Mayow, who, with his predecessor Rey, demonstrated the necessity of atmospheric air in the process. The attention of Chemists was drawn from these subjects early in the eighteenth century, by the new train of investigation in which Dr Black had successfully embarked, and the field of Pneumatic Chemistry, which was so eminently cultivated by Priestley, Scheele, and Cavendish, absorbed universal attention.

The ideas of the ancients concerning the Elements were now completely subverted. The air we breathe was proved to consist of two distinct aeriform fluids—the one a powerful supporter of combustion and respiration, the other extinguishing flame and exterminating life. Water, so long considered as a primitive body, had been resolved into simpler forms of matter; in short, novelties of the most attractive kind presented themselves on every side.

The discovery of hydrogen was seized upon by the advocates of phlogiston, as supporting their hypothesis, and it was generally considered as identical with that substance, which had long been hypothetical, but was now exhibited in a tangible form. The reduction of the metallic calces, by hydrogen, was considered as a powerful argument in favour of these notions, and wherever phlogiston had been supposed to be absorbed or evolved, hydrogen seemed to play the part of that imaginary principle.

The views of Priestley and Scheele were combated by a host of petty controversialists, whose names are yet extant, but whose writings are sunk into oblivion—they brought into the field an army of words, but not a single observation, founded upon fact or experiment. Mr Cavendish was more strenuously and respectably opposed: among those who stood up against his theoretical views, Mr Kirwan deserves especial mention, for he laid other departments of Chemistry under considerable obligations; but his arguments and learning were of little avail against the tried and sterling facts which he questioned; they are no creditable records to the author, but serve to show the feebleness of subtilty when opposed to the strength of truth.

SECTION VI.

INVESTIGATIONS OF LAVOISIER.

Among the eminent scientific characters who adorned the last century, Lavoisier has always been looked upon with high consideration. That his talents were shining, and his career brilliant, cannot be denied; but that he has those high claims to originality which we have been obliged to allow his exalted rivals, has been doubted by the generality of historians, and denied by those who have had access to the most correct information. I shall briefly notice his most important investigations, and afterward endeavour to sketch his character as a Philosopher.

The phenomena of combustion were with Lavoisier, as with his predecessors in the field of theoretical chemistry, a leading object of attention; and the theory of latent heat, devised by Dr Black, was assumed as the ground-work of his new views.

It has already been stated, that, during the conversion of solids into fluids, and of fluids into vapours, there is a considerable absorption of heat; and that, on the other hand, when vapours and liquids are restored to the fluid and solid form, the heat which they contained is evolved, or passes from the latent to the sensible or thermometric state. These views were assumed by the French school as the basis of their theory of combustion. The gas called by Priestley dephlogisticated air, and by Lavoisier oxygen, was regarded as a compound of a peculiar ponderable basis, united to the matter of light and heat. During the process of combustion, the basis was represented as combining with the combustible, augmenting its weight, and changing its properties; whilst the imponderable elements of the gas, the light and heat, were said to be developed in the form of flame.

Lavoisier instituted an extended and beautiful series of researches connected with this subject. Dr Ingenhouz had devised the brilliant experiment of burning iron wire in oxygen, but had neglected any inquiry into the change suffered by the gas and the metal. Lavoisier ascertained that the iron was converted into the black brittle substance, called *martial ethiops* by the old chemists, and that 100 grains of iron absorbed about 100 cubical inches of the gas, and increased 35 grains in weight. Hence martial ethiops appeared to be a compound of oxygen and iron.

Phosphorus was burned in the same manner. There was a considerable absorption

of the gas, and it appeared that the phosphorus had sustained a precisely equivalent increase of weight.

The general conclusions deduced from these experiments were bold, but incorrect. It was assumed that oxygen must be present in all cases of combustion; that the base of the gas always unites to the burning body, and that the heat and light essential to the aeriform state of the oxygen are consequently thrown off, or rendered sensible. With regard to the necessity of the presence of oxygen, it may be remarked, that the cases are very numerous in which bodies burn, and vividly too, independent of that principle, although it is perfectly true that, in the generality of instances, oxygen feeds the flame.

It is, therefore, more philosophical to consider combustion, or the evolution of heat and light, as a general result of intense chemical action, and as ensuing in all cases where it may be conceived that the corpuscles of bodies are thrown into violent motion, than as depending upon the presence of any distinct substance, or ensuing from the mutual actions of any appropriate forms of matter.

But farther; there are many cases in which oxygen unites to bodies, without the evolution of heat and light, as during the gradual change of some of the metals by exposure to air. And there are numerous instances in which vehement combustion ensues, not only where there is no condensation of air, but where gaseous matter is positively produced, as in the inflammation of gunpowder; and hence the theory of latent heat, as applied to the composition of gases, is insufficient to account for the phenomena.

Another weak part of the French hypothesis is that relating to the evolution of light, which, if derived from the gas, should be proportional to its consumption or solidification, whereas it depends chiefly on the combustible. Richter, Delametherie, and Gren, regarded the gas as affording the heat only, which is proportional to the quantity consumed; and they supposed the evolution of light to be derived from the combustible, and several modern chemists have espoused this explanation. Phosphorus emits much more light than hydrogen, but consumes less oxygen; hence we should regard phosphorus as containing more combined light than hydrogen. This hypothesis involves several unnecessary suppositions; but these cannot be discussed without reference to subjects which are excluded by the limits of this discourse. It may, however, here be observed, how nearly the French theory of combustion agrees with that of Rey and Mayow, in referring the increase of weight of the

combustible, to the fixation of air: this was the great obstacle in the phlogistic hypothesis, and Rey and Lavoisier overcame it by the same means.

Oxygen was not merely considered by the French school as necessary to combustion, but also as an essential ingredient in all acids (whence the term *oxygen*); but there are many acids in which no oxygen can be proved to exist, and it is now known even to form a component part of the alcalies and earths. 'If sulphur be burned in oxygen, it produces sulphurous acid gas: if potassium be heated in sulphurous acid gas, it robs the sulphur of its oxygen, and is converted into potash; here oxygen is seen alternately producing an acid and an alcali,—the result depending not upon the oxygen, but upon the base with which it combines.

In detailing the discoveries of Dr Black, I was led to notice his researches concerning the production of fixed air. This gas was also examined with much attention by Priestley, Scheele, and Cavendish, and they have each made important additions to our knowledge of its sources and properties.

Lavoisier's inquiries respecting the composition of fixed air, and its production during the combustion of charcoal and of the diamond, were highly important as connected with his general theoretical views. Black had indeed ascertained that burning charcoal produced fixed air, but rested satisfied with the mere fact, and pursued not the inquiry which it naturally suggested, and which was eagerly taken up by Lavoisier at an early period of his scientific career. He burned a given weight of charcoal in a given proportion of oxygen gas confined over quicksilver, and when the vessel had cooled, he introduced a solution of potash, which absorbed the fixed air. He thus ascertained the bulk of the fixed air generated by the charcoal, and the bulk of oxygen consumed; and, by weighing the residuum of the charcoal, he found the quantity lost by its combustion. From such experiments, he was led to regard fixed air as composed of oxygen and charcoal, in the proportions by weight of about 70 of the former and 30 of the latter. Soon after the discovery of fixed air by Black, it was demonstrated by Keir, Bergman, and Fontana, to possess acid properties; hence it was occasionally termed aërial acid, cretaceous acid, and mephitic acid. Consistently with the principles of the new nomenclature, it received from Lavoisier the name of carbonic acid, a term implying that it is composed of charcoal and oxygen; and this it has since retained.

The production of fixed air, or, as we may now call it, carbonic acid, during the combustion of diamond, is one of the most remarkable and important discoveries with which Lavoisier enriched chemical science. The destruction of this precious gem by

fire was demonstrated by the Florentine academicians as early as 1690 ; they exposed a diamond to the focus of a burning lens, and found that it was entirely evaporated ; and Francis the First, of Germany, witnessed the same phenomenon in the heat of a furnace. Lavoisier proved that the diamond underwent no change when air was excluded ; and that, when ignited in oxygen gas, it produced carbonic acid ; whence the inevitable conclusion that the diamond and charcoal are identical in their nature ; and that the vast difference in their appearance and mechanical qualities is the result of aggregation ; that the one is crystallized, the other in a less indurated form. Unprecedented as such an idea may seem, it is not only warranted by the experiments of Lavoisier and others, but also in some degree supported by analogy. Thus, when argillaceous earth, which is a white pulverulent substance, is aggregated by mechanical attraction into a crystalline form, it constitutes the sapphire, one of the hardest and least destructible of the gems. In one state, the earth is soft, and readily soluble in acids ; in the other, its insolubility equals its induration : but there is one invincible anomaly relating to the conducting power of the diamond and charcoal in regard to electricity ; the former ranks among the non-conductors, the latter is a conductor ; and hitherto mechanical texture has not been shown, in any analogous cases, to interfere with the power of conducting electricity.

Among those who have further explored the phenomena of the combustion of the diamond, and who have verified and extended the original views of Lavoisier, we find the names of the most eminent European Philosophers. Few subjects in Chemistry have been so eagerly pursued, and the united results of different experimentalists have rarely tallied with the precision which these researches present. [1]

The discoveries of Rutherford and of Priestley, in the years 1772 and 1774, had dis-

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[1] That the quantity of carbonic acid, afforded by a given weight of diamond, is the same as that yielded by a similar quantity of charcoal, is the great proof of the identity of those apparently dissimilar substances : this was demonstrated in the year 1796, by the refined and elegant experiments of Mr Tennant, whose untimely loss society has lately had to deplore. Mr Tennant was a profound philosopher, and a matchless companion,—his learning was without pedantry ; his wit without sarcasm,—he was deep, but always clear; gentle, but never dull. To those who knew him not, it is scarcely possible to offer an adequate representation of his singularly pleasing and enlightened character,—by those who enjoyed his acquaintance, and partook of his social hours, his extent of knowledge, his happy and unrivalled talent for conversation, his harmless but brilliant flashes of merriment, and all his amiable peculiarities, can never be forgotten. Friendship will long continue to weep over his grave, and science to lament beside his tomb.

Mr Tennant was born in Yorkshire in 1761, and died at Boulogne in 1815.

See *Biographical Account* of Smithson Tennant, Esq. in Thomson's *Annals of Philosophy*, Vol. VI.

closed the elements of atmospheric air, and several experiments respecting the proportions in which they are blended, had been instituted by these, and other Philosophers. In the year 1775, Lavoisier resumed these inquiries, with a masterly and decisive hand; he heated mercury in contact with a known portion of atmospheric air; it gradually acquired a red film, which after some days ceased to form, and the metal remained unaltered; he then withdrew the fire, and suffered the vessels to cool; he found that the air had diminished in bulk, and that the quicksilver had increased in weight; that the loss of the former was equivalent to the gain of the latter—which had absorbed the oxygen of the air, leaving the azote unaltered. By such investigations he arrived, with tolerable precision, at the proportion in which these gases exist in common air, and found, that, by mixing forty-two parts, by measure, of azote with eight parts, by measure, of oxygen, he produced a compound precisely resembling our atmosphere, in its power of supporting combustion and respiration, and of contributing to the calcination of the metals.

Besides these researches and discoveries, Lavoisier was the author of many scientific papers in the *Memoirs of the Parisian Academy.* Of these a brief and hasty notice will suffice, as they relate not to the great reform of chemical theory, in which he was so conspicuous an actor, and upon which his fame and reputation have chiefly been raised.

In 1764, the French Government proposed, as a prize question, "Which is the best method of illuminating the streets of a large metropolis?" It was answered by Lavoisier; and he was rewarded with an honorary medal. In 1768, he became a member of the Academy. In 1770, he controverted a prevailing opinion respecting the convertibility of water into earth; and, two years afterwards, published an ingenious geological essay upon the changes and stratification of the globe. In 1774, he entered upon the grand field of discovery which has occupied so much of our attention, and published an ingenious and comprehensive view of Pneumatic Chemistry. A few years afterwards, his theory of acidity, of combustion, and of oxidizement; his experiments upon the composition of water, and of the atmosphere, and his views respecting the nature and affections of heat, were successively presented to the public; and, in 1789, his work entitled *Elemens de Chimie* was given to the world. It contains a full account of his theoretical views and experimental researches.

Lavoisier was an earnest promoter of the Chemistry of the Arts. He turned his attention to the improvement of several manufactures, and his labours were rewarded by considerable success. Agriculture was with him a favourite pursuit, and he en-

deavoured to improve its processes by experimental research. He was an able Political Economist; and, for a few years, filled the office of a Commissioner of the National Treasury, with honour to himself, and benefit to his country.

The moral and social character of Lavoisier was of the most estimable cast. Contemporary historians agree in eulogizing his mild, amiable, and obliging manners; in extolling his liberality, and in praising him, as the encourager of deserving ingenuity, and the ardent patron of science and the arts.

Through the scenes of the Revolution, such a man could not expect to pass unmolested. He was rich, and therefore criminal; virtuous, and consequently offensive. In short, because his public character and private life were equally unimpeachable and blameless, he was marked out for destruction, and murdered upon the scaffold on the 8th of May 1794, in his native city of Paris, and in the 51st year of his age.

Upon these acts of iniquitous barbarity and inhuman treachery, equally degrading to the individual performers and to the beholding nation, it is neither my business nor inclination to dwell; the recital of particulars would excite disgust rather than interest; and would rather shock than inform.

We must now divest ourselves of the impressions naturally arising out of the virtues, the eminence, and the misfortunes of Lavoisier, and with unmixed attention steadily reflect upon his philosophical character. By some he has been extolled as the most original, inventive, and exalted genius of his age; by others stigmatized as an universal and dishonourable plagiarist; but these are the extremes of panegyric and malevolence, each equidistant from candour and from truth. He was doubtless an acute, sagacious, and useful Philosopher; his zeal for the welfare of science was unremitting and exemplary, and his affluence enabled him to pursue it upon an extensive and splendid scale. As an original discoverer, he bends before Black and Priestley, and was inferior to Cavendish and Scheele; but, as a theorist, he has few equals; he was comprehensive, successful, and clear. If time has shaken his opinions, and loosened his speculations, the change must be referred to the imperfect and progressive state of Chemistry, rather than to their inherent futility. In Natural Philosophy, the systems of Pythagoras, Ptolemy, Descartes, and others, have successively yielded to the satisfactory and apparently stable simplicity of the Newtonian doctrines; but the Newton of Chemistry is yet to come.

It must be regretted, that those who have censured Lavoisier with the uncandid and unacknowledged appropriation of the thoughts of others, have some grounds for

the accusation. In bringing forward his theory of combustion; why did he smother the lucid opinions of Rey and Mayow? why refuse praise and acknowledgment to Black, and Scheele, and Cavendish? or, why appropriate the discovery of oxygen, in the face of the prior, indisputable, and known claims, of his friend and contemporary Priestley? These are questions we cannot now answer; but, those who have grounded harsh, indiscriminate, and severe censure, upon such accusations, have neither been animated by the independent spirit of true philosophy, nor guided by the unbiassed love of truth. It must be remembered, that Lavoisier was never fairly confronted by these rivals and antagonists; that unintentional inadvertency often accompanies scientific ardour; that, in the eagerness of pursuit, he may have neglected that which, in a calmer hour, he would have seen, regretted, and acknowledged; and that, in the hurry of discussion and heat of controversy, he was suddenly summoned to eternity.[1]

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[1] Since writing the above, I have seen two scarce volumes of the posthumous works of Lavoisier in Mr Hatchett's library at Roehampton. They consist, in great measure, of extracts from, and sketches of his different papers read before the Royal Academy of Sciences, but several original Observations and Essays are also dispersed among them. They, in some degree, justify the observation which I have made in the text, that, had Lavoisier lived, he would have done merited justice to his predecessors and contemporaries, for he candidly reviews their opinions, and compares them with his own; at the same time, the following passage cannot be regarded as perfectly candid towards Rey, who, as I have shown above, founded his arguments not upon hypothesis, but upon experiment.

I insert a long quotation, that there may be no misunderstanding upon the subject.

After stating the prevailing phlogistic notions entertained at that period, he proceeds as follows: " Tel étoit l'etat des connoissances, lorsqu'une suite d'expériences, entreprises en 1772 sur les différentes espèces d'air, ou de gaz qui se dégagent dans les effervescences et dans un grand nombre d'opérations chimiques, me firent connoître, d'une manière démonstrative, quelle étoit la cause de l'augmentation de poids, qu'acquiérent les metaux lorsqu'on les expose à l'action du feu. J'ignorois alors ce que Jean Rey avoit écrit à ce sujet en 1630; et quand je l'aurois connu, je n'aurois pu regarder son opinion à cet égard, que comme une assertion vague, propre à faire honneur au génie de l'auteur, mais qui ne dispensait pas les chimistes de constater la verité de son opinion par des expériences. J'étois jeune, j'étois nouvellement entré dans la carrière des sciences, j'étois avide de gloire, et je crus devoir prendre quelques précautions pour m'assurer la propriété de ma découverte. Il y avoit à cette époque, une correspondance habituelle entre les savans de France et ceux d'Angleterre; il regnoit entre les deux nations, une sorte de rivalité qui donnoit de l'importance aux expériences nouvelles, et qui portoit quelquefois les écrivains de l'une ou de l'autre nation, à les contester à leur véritable auteur; je crus donc devoir déposer, le 1er Novembre 1772, l'écrit suivant cacheté, entre les mains du Secrétaire de l'Académie. Ce dépôt a été ouvert à la séance du 5me Mai suivant, et mention du tout a été faite en tête de l'écrit. Il étoit conçu en ces termes:—

" Il y'a environ huit jours que j'ai découvert, que le soufre en brûlant, loin de perdre de son poids, en acquiéroit au contraire; c'est à dire, que d'une livre de soufre, on pouvoit retirer beaucoup plus d'une livre d'acide vitriolique, abstraction faite de l'humidité de l'air; il en est du même du phosphore: cette augmentation de poids vient d'une quantité prodigieuse d'air qui se fixe pendant la combustion, et qui se combine avec les vapeurs.

Though these considerations do not exculpate our philosopher, they must be allowed to extenuate his imputed failings—they should induce us rather to soften the asperities of his scientific character, than to magnify its faults—instead of rejoicing that he was not perfect, we should delight in his excellence, and should estimate his character as a Philosopher, not so much by the means he employed, as by the noble effects produced.

Among many other subjects which engaged the attention of Lavoisier and his associates, that of reforming the nomenclature of Chemistry deserves to be noticed as highly beneficial to the promotion of the science, and as tending materially to facilitate its acquisition. I am inclined, however, to think that, upon this point, too much credit has been given to the French school; rage for innovation, and not zeal for improvement, seems often to have guided the undertaking; and terms, once deemed faultless, now appear not less absurd and objectionable than the fanciful names employed by the alchemical writers.

As principals in the formation of the new nomenclature, we find the names of Guyton Morveau[1] and Fourcroy, two men who may certainly be considered as ornaments of their age and country. The former, amidst varied avocations, prosecuted Chemistry

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"Cette découverte que j'ai constatée par des expériences que je regarde comme décisives, m'a fait penser que ce qui s'observoit dans la combustion du soufre et du phosphore, pouvoit bien avoir lieu à l'égard de tous les corps qui acquiérent du poids par la combustion et la calcination : et je me suis persuadé, que l'augmentation de poids des *chaux* métalliques, tenoit à la même cause. L'experience a complettement confirmé mes conjectures : j'ai fait la reduction de la litharge dans des vaisseaux fermés, avec l'appareil de Hales, et j'ai observé qu'il se dégagéoit, au moment du passage de la *chaux* en métal, une quantité considérable d'air, et que cet air formoit un volume au moins mille fois plus grand que la quantité de litharge employée. Cette découverte me paroissant une des plus intéressantes qui ait été faite depuis Stahl, j'ai cru devoir m'en assurer la propriété, en faisant le present dépôt entre les mains du Secrétaire de l'Académie, pour demeurer secret jusqu'au moment où je publierai mes experiences."

(Signé) "Lavoisier."

"En rapprochant cette première notice de celle que j'avois déposée à l'Académie le 20^{me} Octobre précédent, sur la combustion du phosphore, du mémoire que j'ai lu à l'Académie à sa séance publique de Pâques 1773, enfin, de ceux que j'ai successivement publiés, il est aisé de voir, que j'avois conçu dés 1772, tout l'ensemble du systême que j'ai publié depuis sur la combustion. Cette théorie à laquelle j'ai donné de nombreux développemens en 1777, et que j'ai porté, presque dés cette époque à l'état où elle est aujourdhui, n'a commencé à être ensignée par Fourcroy, que dans l'hyver de 1786 à 1787; elle n'a été adoptée par Guyton Morveau, qu'à une époque postérieure; enfin, en 1785 Berthollet écrivoit encore dans le systême du phlogistique. *Cette theorie n'est donc pas, comme je l'entends dire, la théorie des Chimistes François : elle est la mienne*, et c'est une propriété que je réclame auprés de mes contemporains et de la postérité."

[1] Born at Dijon in 1737. Died at Paris in 1815. See *Life* by Dr Granville in the *Journal of Science and Arts*, Vol. III. p. 249.

with successful diligence, and, had he given nothing else to the science, his name deserves to be transmitted to posterity, as the inventor of the means of destroying infection by acid vapours, the efficacy of which he first pointed out in the year 1773. His first essay on the reform of nomenclature was published in the *Journal de Physique* for May 1782, and although it was strenuously opposed by the colossal power of the Royal Academy of Paris, the plan was not only afterwards approved, but prosecuted by the eminent Chemists of that metropolis. The different papers and correspondence relating to this subject are, in many respects, curious and interesting from the difference of opinion which prevailed respecting the terms he adopted, and the ultimate benefit likely to result from the reformation.

Fourcroy [1] is a well known name in the chemical world; his works rank among the most celebrated which France has produced in the science of Chemistry, though they are sometimes deficient in candour, and sometimes in correctness. His labours were important, and his discoveries numerous, but they are, in many respects, so closely interwoven with those of contemporary Philosophers, that I have deemed it expedient to waive farther notice respecting their objects and merits.

I have now brought my narrative to the conclusion of the last century, about which period Electricity began to assume importance as a chemical agent, and the *Voltaic* apparatus became a necessary implement of the laboratory. To this source, the new aspect which chemical science now wears, may principally be referred, and the historian, who shall in aftertimes record the advances that have been made in Chemistry during the last eighteen years, will recite triumphs of the human mind never excelled, and rarely equalled.—I am apprehensive that the inquisitive eye will detect several omissions in the foregoing pages, although I have diligently endeavoured to record every important event in the general history of the science. Of many who have attained deserved eminence in the exclusive pursuit of its distinct branches, no mention has been made: I have looked with attention into their works, and am well aware of their individual merits; but I should have swerved from the principal object of this Dissertation, that of recording discoveries, had I attempted even the superficial enumeration of their infinitely varied applications.

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[1] Born in Paris in 1755, where he died in 1809.

ERRATA.

Page 23, line 16, *for* potash *read* soda.

Page 53, last line, *for* 1733 *read* 1773.

Supplement

TO THE

ENCYCLOPÆDIA BRITANNICA.

CHEMISTRY.

SINCE the publication of the article Chemistry, in the *Encyclopædia Britannica*, that science has been so much extended and improved as to have acquired an entirely new character. And although we have given a full account of a most important branch of this improvement in our article under the head ATOMIC THEORY, it is conceived, that a connected view of the present state of Chemical Philosophy, will add much to the utility of the present work. This we shall endeavour to give in the most condensed form consistent with perspicuity.

Chemistry takes cognizance of all changes in the constitution of matter, whether effected by heat, mixture, or other means. Its general range, therefore, is so extensive, and the individual cases, requiring explanation, so numerous, that *Arrangement* is of the first consequence to its successful study; and, in the present state of our knowledge, it will be found most convenient to begin with the discussions relating to the general powers or properties of matter, and afterwards to proceed to the examination of individual substances, and to the phenomena which they offer when presented to each other under circumstances favourable to the exertion of their mutual chemical agencies.

The powers and properties of matter, connected with chemical changes, may be considered under the heads of

1. Attraction.
2. Heat.
3. Electricity.

I. ATTRACTION.

Attraction may be regarded as acting at sensible and at insensible distances. In the former case, it is called gravitation. It is the power by which substances are propelled towards the earth; it exists in all known forms of matter, and acts directly as the mass, and inversely as the square of the distance: And, when restrained by *inertia*, it preserves the planetary bodies in their orbits, presides over their movements, and tends to confer upon the system of the universe that consummate harmony which the genius of Newton has unveiled.

Attraction is also exerted at insensible distances, and among the minutest atoms of matter. It thus preserves the form and modifies the texture of solids, gives a spherical figure to fluids, and influences the mechanical characters of bodies; and, when it operates upon *dissimilar* particles, it produces their union, giving rise to new and infinitely varied productions.

The results of attraction, as relating to the forms of matter, are influenced by the circumstances under which it has taken place. Sometimes the particles are, as it were, indiscriminately collected; in other cases they are beautifully arranged, giving rise to regular and determinate figures. In this case, bodies of the same composition invariably affect the same form; hence we are often enabled to infer the composition of a substance from accurate inspection of its external or mechanical characters. The regular polyhedral solids thus resulting from the influence of attraction upon certain kinds of matter, are usually called crystals, and the bodies are said to be susceptible of crystallization. To enable the particles of bodies to assume that regular form which crystals exhibit, it is obvious, that they must have freedom of motion, and, accordingly, the first

Chemistry.

step towards obtaining a body in its crystalline form, is to confer upon it either the liquid or aëriform state. The former is usually effected by solution in water; the latter by exposure to heat. When common salt is dissolved in water, its particles may be regarded as disposed at regular distances throughout the fluid; and if the quantity of water be considerable, the particles will be too far asunder to exert reciprocal attraction; in other words, they will be more powerfully attracted by the water than by each other. If we now slowly get rid of a portion of the water by evaporation, the saline particles will gradually approach each other, and they will aggregate according to certain laws, producing a regular solid of a cubic form. The regularity of this figure will be influenced by the rapidity of the evaporation; if the process be slowly conducted, the particles unite with great regularity; if hurried, the crystals are irregular and confused. In common cases, the evaporation may be continued till a pellicle forms upon the surface of the solution, which indicates, that the attraction of the saline particles for each other, is becoming superior to their attraction for the water. The formation, therefore, of a superficial pellicle is the common criterion of the fitness of a solution for crystallization; but where the object is to obtain very regular and very large crystals, the evaporation must be much slower, and carried to much less extent; even spontaneous evaporation, or that which takes place at common temperatures, must be resorted to. There are certain bodies which may be dissolved or liquified by heat, and, during slow cooling, may be made to crystallize. This is the case with many of the metals, and with sulphur. Some other substances, when heated, readily assume the state of vapour, and, during condensation, present regular crystalline forms, such as iodine, benzoic acid, camphor, &c. The hardness, brilliancy, and transparency of crystals, often depend upon their containing water, which sometimes exists in large quantities. Thus, sulphate of soda, in the state of crystals, contains more than half its weight. This is called *water of crystallization*. Some salts part with it by simple exposure to a dry air, when they are said to effloresce; but there are other salts which deliquesce, or attract water from the atmosphere.

Crystallization.

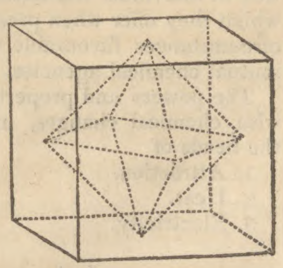
Crystallization is accelerated, by introducing into the solution a nucleus, or solid body, upon which the process begins; and manufacturers often avail themselves of this circumstance. Thus we see sugar-candy crystallized upon strings, and verdigris upon sticks. There are cases in which it is particularly advantageous to put a few crystals of the dissolved salt into the solution, which soon cause a crop of fresh crystals; and in some instances, if there be two salts in solution, that will most readily separate, of which the crystals have been introduced. A strong saline solution, excluded from the air, will frequently crystallize the instant that air is admitted, —a circumstance referred to atmospheric pressure. In other cases, agitation produces the same effect. These phenomena seem connected with the doctrine of latent heat. The presence of light also influences the process of crystallization. Thus we see the crystals collected in camphor bottles in druggists' windows always most copious upon the surface exposed to light; and if we set a solution of nitre in a room which has the light admitted only through a small hole in the window-shutter, crystals will form most abundantly upon the side of the basin exposed to the aperture through which the light enters.

We may now proceed to examine the structure of crystallized bodies, upon which the *Theories of Crystallization* are founded. This inquiry exposes the connecting link between Chemical and Mechanical properties of bodies.

It is commonly observed, that crystallized bodies affect one form in preference to others. The fluor spar of Derbyshire crystallizes in cubes: so does common salt. Nitre assumes the form of a six-sided prism, and sulphate of magnesia that of a four-sided prism. These forms are liable to vary. Fluor spar and salt crystallize sometimes in the form of octoëdra, and there are so many forms of carbonate of lime, that it is difficult to select that which most commonly occurs.

Romé de Lisle referred these variations of form to certain truncations of an invariable primitive nucleus; and Gahn afterwards observed, that when a piece of calcareous spar was carefully broken, all its particles were of a rhomboidal figure. This induced Bergman to suspect the existence of a primitive nucleus in all crystallized bodies. When Haüy* entered this field of inquiry, he not only corroborated the opinions of Bergman, and submitted former hypotheses to experimental proof, but traced with much success the laws of crystallization, and pointed out the modes of transition from primitive to secondary figures.

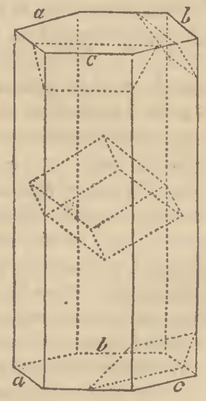
Those who are in the habit of cutting and polishing certain gems, have long known that they only afford smooth surfaces when broken in one direction; and that in others the fracture is irregular and uneven. This is the case with crystallized bodies in general. If we attempt to split a cube of fluor spar with the blade of a knife, assisted by a hammer, we shall find that it will only yield kindly in the direction of the solid angles; and pursuing the division in these directions, an octoëdron will be the resulting figure, as in this diagram.



In splitting a six-sided crystal of calcareous spar, we find that, of the six edges of the superior base, three alternate edges only will yield to the blow; those, for instance, marked *a*, *b*, *c*; and the division will take place in a plane inclined at an

* *Traité de Mineralogie*. Paris, 1801.

angle of 45°. The three intermediate edges resist this division. But in dissecting the inferior base of the crystal, the intermediate edges will alone yield, namely *a*, *b*, *c*. If we continue this dissection in the same directions, we shall at length obtain the obtuse rhomboid, which is seen in this diagram in its relative situation to the including prism.



We thus then arrive at the primitive form of the calcareous spar, and from whatever secondary form it has been obtained, it is always a rhomboid, having obtuse angles of 105°. But an obtuse rhomboid is also the primitive form of other bodies, as of pearl spar, iron spar, and tourmalin. But here the inclination of the surface points out a difference. Thus the primitive angle of pearl spar is 106° 5′, of iron spar 107°,* and of tourmalin 113° 10′.

These instances show the necessity of being provided with instruments for measuring the angles of crystals with nice accuracy; they are termed *goniometers*. The reflective goniometer, invented by Dr Wollaston,† is the most useful of these instruments. It enables us to determine the angles even of minute crystals with great accuracy; a ray of light reflected from the surface of the crystal being employed as radius, instead of the surface itself.

In following the method above described, having obtained six primitive forms,

1. The cube, parallelopipedon, &c.
2. The tetraëdron.
3. The octoëdron.
4. The hexangular prism.
5. The rhombic dodecaëdron.
6. The dodecaëdron with triangular faces.

These primitive forms, by further mechanical analysis, may be reduced to three *integral elements*.

1. The parallelopiped, or simplest solid, having six surfaces parallel, two and two.
2. The triangular, or simplest prism, bounded by five surfaces.
3. The tetraëdron, or simplest pyramid, bounded by four surfaces.

The secondary forms are supposed to arise from decrements of particles taking place on different edges and angles of the primitive forms. Thus a cube, having a series of decreasing layers of cubic particles upon each of its six faces, will become a dodecaëdron, if the decrement be upon the edges; but an octoëdron, if upon the angles; and by irregular intermediate and mixed decrements, an infinite variety of secondary forms would ensue.

But in crystallography we meet with appearances which Haüy's theory but imperfectly explains. A slice of Derbyshire spar, for instance, obtained by making two successive and parallel sections, may be divided into acute rhomboids; but these are not the primitive form of the spar, because, by the removal of a tetraëdron from each extremity of the rhomboid an octoëdron is obtained. Thus, as the whole mass of fluor may be divided into tetraëdra and octoëdra, it becomes a question which of these forms is to be called primitive, especially as neither of them can fill space without leaving vacuities, nor can they produce any arrangement sufficiently stable to form the basis of a permanent crystal. To obviate this incongruity, Dr Wollaston‡ has very ingeniously proposed to consider the primitive particles as spheres which, by mutual attraction, have assumed that arrangement which brings them as near as possible to each other. When a number of similar balls are pressed together in the same plane, they form equilateral triangles with each other; and if balls so placed were cemented together and afterwards broken asunder, the straight lines in which they would be disposed to separate, would form angles of 60° with each other. A single ball, placed any where on this stratum, would touch three of the lower balls, and the planes touching their surfaces would then include a regular tetraëdron. A square of four balls, with a single ball resting upon the centre of each surface, would form an octoëdron, and upon applying two other balls at opposite sides of this octoëdron, the group will represent the acute rhomboid. Thus the difficulty of the primitive form of fluor, above alluded to, is done away, by assuming a sphere as the ultimate molicula. By oblate and oblong spheroids other forms may be obtained. The subject of crystallization has more lately engaged the attention of Mr J. F. Daniell,|| and his researches have produced some singular confirmations of Dr Wollaston's hypothesis. If an amorphous piece of alum be immersed in water, and left quietly to dissolve, at the end of about three weeks we shall observe that it has been unequally acted upon by the fluid: the mass will present the forms of octoëdra, and sections of octoëdra, as it were carved or stamped upon its surface, as seen in these figures:

* *Wollaston. Phil. Trans.* 1812.
† *Phil. Trans.* 1809.
‡ *Phil. Trans.* 1813. Some acute remarks on the formation of crystals may be found in Hooke's *Micrographia.*
|| *Quarterly Journal of Science and the Arts*, Vol. I.

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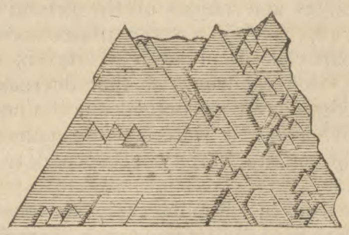
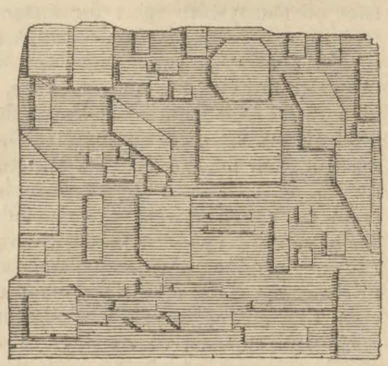
This appearance is produced when the attraction of the water for the solid is nearly counterbalanced by its mechanical texture. The crystals produced by this species of dissection, are highly curious from their modifications and relative positions, as the same group present the primitive form as well as its truncations and decrements. Other salts yield





other figures, and by more complicated chemical action, as of acids upon carbonate of lime, the metals, &c. analogous results are obtained. Here, then, instead of dividing a crystal by mechanical force, its structure is gradually developed by the process of solution. In these cases two circumstances are particularly remarkable: the crystals are different, and their forms vary with the different faces of the original mass. In one direction we observe octoëdra and sections of octoëdra; in another, parallelograms of every dimension, modified with certain determinate intersections.

If, in either of these positions, we turn the mass upon its axis, the same figures will be perceived at every quadrant of a circle; and, if we suppose the planes continued, they will mutually intersect each other, and various geometrical solids will be constructed. In this way, alum alone furnishes octoëdrons, tetraëdrons, cubes, four and eight-sided prisms, either with plain or pyramidal terminations, and rhombic parallelopipedons. It is evident, then, that no theory of crystallization can be admitted, which is not founded upon such a disposition of constituent particles, as may furnish all these modifications, by mere abstraction of certain individuals from the congeries, without altering the original relative position of those which remain; and these conditions may be fulfilled by such an arrangement of spherical particles, as would arise from the combination of an indefinite number of balls endued with mutual attraction, and no other geometrical solid is adequate to the purpose; and where bodies furnish crystals differing from the octoëdral series, an analogous explanation is furnished, by supposing their constituent particles to consist of oblate spheroids, whose axes bear different proportions to each other in different substances. Hence we may also conclude, that the internal structure of all crystals of the same body is alike, however the external shapes differ. In corroboration of the above hypothesis, we may remark, that the hexaëdron is, of all geometrical figures, that which includes the greatest capacity under the least surface. If, therefore, the ultimate particles of crystalline bodies be spheres or spheroids, the greatest possible number in the least space will be included in this form. It is probable that the exterior shape of every crystal is determined by the nucleus first formed by a certain definite number of particles, which, by the power of mutual attraction, overcome the resistance of the medium in which they were suspended, or from which they were separated. This number may vary with the solvent, or other contingent circumstances. Four spherical particles, thus united, would balance each other in a tetraëdral group, six in an octoëdral group, and each would present particular points of attraction to which all subsequent deposits would be directed. Now, let us imagine two nuclei formed in the same solution, whose axes run in contrary directions; their increase will consequently be in contrary directions, and each will attract a particular system of particles from the surrounding medium. If these two systems should cross each other in their course, a greater number will be brought within the sphere of mutual reaction at the point of junction, and they ought to arrange themselves in the least possible compass. The facts here answer to the theory. If we select any crystals, having others crossing them nearly at right angles, and separate them, the points of junction invariably present an hexaëdral arrangement.

In connection with chemistry, the theory of crystallization opens a new avenue to the science, and frequently enables us to ascertain directly that which, independent of such aids, could only be arrived at by an indirect and circuitous route. We frequently read the chemical nature of substances in their mechanical forms. To the mineralogist, an intimate acquaintance with the crystalline forms and modifications of natural bodies is essentially requisite. Indeed, the theory of crystallization may be considered as one of the great supports of that useful branch of natural history, and it is to the indefatigable exertions of Haüy that much of its present perfection is to be referred. In the arts, the process of crystallization is turned to very valuable account, in the separation and purification of a variety of substances.

Chemical Affinity.

We have hitherto considered Attraction as disposing the particles of bodies to adhere, so as to form masses or aggregates, and, in many instances, to arrange themselves according to peculiar laws, and to assume regular geometrical figures. We are now to regard this power as operating upon dissimilar particles, as presiding over the composition of bodies, and as producing their chemical varieties. This is Chemical Attraction or Affinity. If, into a glass vessel, exhausted of air, be introduced some sulphur, and copper filings, and heat be applied so as to melt the former, it will presently combine with the latter. We observe, as the results of this attraction between the sulphur and copper, 1. That the substance produced has not the intermediate properties of its elements, but that it presents new characters. 2. That much heat and light are evolved during the

mutual action. 3. That sulphur and copper will unite in certain proportions only. In liquids and gases, similar changes of properties may be exhibited, and, in many cases, a change of form or state results. Thus the combination of aëriform bodies produces a solid, as when muriatic and ammoniacal gases produce the solid salt called muriate of ammonia. Solids also produce liquids, and liquids gases. In all cases of true chemical combination, the properties of the compound differ essentially from those of its component parts, and a series of new bodies, possessed of distinct and peculiar characters, are produced. Such operations are not confined to art. Nature presents them on an extended scale, and, in connection with the functions of life, renders them subservient to the most exalted purposes.

The new chemical powers, therefore, that bodies acquire in consequence of combination, are often extremely remarkable, and can only be learned by *experiment*. It frequently happens that inert bodies produce inert compounds, and that active substances remain active when combined; but the reverse often occurs. Thus oxygen, sulphur, and water, in themselves tasteless and comparatively inert, produce *oil of vitriol* when chemically combined; and potash, which is a powerful caustic when combined with oil of vitriol, forms a salt possessed of little activity. As chemical action takes place among the ultimate or constituent elements of bodies, it must obviously be opposed by the cohesion of their particles, and chemical attraction is often prevented by mechanical aggregation. A piece of the metal antimony, put into the gas called chlorine, is only slowly and superficially acted upon; but if the mechanical aggregation be previously diminished, by reducing the metal to powder, it in that state rapidly unites with the gas, and burns the instant that it is introduced. Heat increases the chemical energies of bodies. Its effects are sometimes only referable to the diminution of adhesion by expansion, but in other cases are peculiar and complicated, as will be shown under the sections on Heat and Electricity.

Bodies are possessed of very different attractive powers, and if several be brought together, those which have the strongest mutual affinities enter first into union. Thus, if nitric acid be poured upon a mixture of lime and magnesia, it dissolves the former in preference to the latter earth. The knowledge of this fact enables us to separate bodies when united, or to perform the process of decomposition. Thus, if I add an aqueous solution of lime to a solution of magnesia in nitric acid, the latter earth is thrown down or precipitated, and the lime occupies its place in the acid.

Decomposition is effected under a variety of circumstances, and by many methods; but it is commonly described by chemists as Simple and Complex, or Single and Double.

In cases of simple attraction or affinity, one body separates another from its combination with a third. Thus, when potash is added to a solution of sulphate of zinc (composed of sulphuric acid and oxide of zinc), the oxide of zinc is separated, and sulphate of potash is produced.

In cases of double decomposition, two new compounds are produced; as when a solution of nitrat of barytes is mixed with solution of sulphate of soda, the results are a precipitate of sulphate of barytes, and a solution of nitrat of soda.

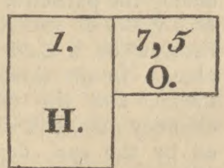
It is obvious, from the uniform results of chemical action, that affinity must be governed by certain definite laws, by which its results are determined, and upon which its uniformity depends. Attention was first called to this subject by Mr Higgins in 1789.* He conceived that chemical attraction only prevailed between the ultimate particles of simple elementary matter and between compound atoms; and, in applying this idea to chemical theory, he expressed by numbers the relative forces of attraction subsisting between the different kinds of ultimate particles and atoms of matter.

These views were subsequently extended and improved by Mr Dalton,† and have since engaged the attention of some most eminent chemical philosophers; among whom we may enumerate Gay Lussac and Berzelius, Davy, Wollaston, and Thomson.

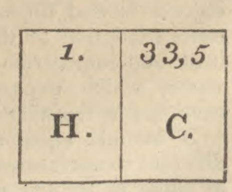
Definite Proportions.

The atomic doctrine, or theory of definite proportions, has been much blended with hypothetical views; but it will be most satisfactorily and usefully considered as an independent collection of facts.

When bodies unite so as to form one compound only, that compound, under whatever circumstances it is produced, whether by nature or art, always contains the same relative proportions of its components; and where two bodies unite in more than one proportion, the second, third, &c. proportions are multiples or divisions of the first. This law is well exhibited in the combinations of gaseous bodies. These are seen to unite in simple ratios of volume. Water is composed of hydrogen and oxygen, and 1 part by weight of the former gas, unites to 7,5 of the latter. The specific gravity of hydrogen, compared with that of oxygen, is as 1 to 15: it is obvious, therefore, that one volume of hydrogen unites to half a volume of oxygen, and that the composition of water will be represented by weight and volume thus:



Muriatic acid gas consists of 1 part by weight of hydrogen, and 33½ by weight of chlorine. The relative specific gravities of these gases are as 1 to 33,5. It is obvious, therefore, that they combine in equal volumes, and that muriatic acid gas may be thus represented.



* *A Comparative View of the Phlogistic and Antiphlogistic Theories*, &c. London, 1789.

† *New System of Chemical Philosophy*. Manchester, 1810.

Carbonic acid unites to potash in two proportions, and forms two definite compounds. In the one, 70 parts of potash are combined with 30 of carbonic acid; in the other, 70 of potash are united to 60 of carbonic acid. Lead combines with oxygen in three proportions; the first compound consists of 100 lead + 8 oxygen, the second of 100 + 12, the third of 100 + 16.

Bodies are always obedient to these laws of union; and, in whatever way they are produced, their component parts exist in the same relative proportions.

Heat.

Heat may be considered as a power opposed to Attraction, for it tends to separate the particles of bodies; and whenever a body is heated, it is also expanded. Expansion is the most obvious and familiar effect of heat; and it takes place, though in different degrees, in all forms of matter. Solids are the least expansible,—liquids expand more readily than solids,—and gases or aëriform bodies more than liquids. When a body has been expanded by heat, it regains its former dimensions when cooled to its former temperature. Different bodies expand differently when equally heated. The metals are the most expansible solids; but among them, zinc expands more than iron, and iron more than gold. Liquids differ also in their relative expansibilities. Ether is more expansible than spirit of wine, and spirit more than water, and water more than mercury. Those liquids are generally most expansible which boil at the lowest temperature. In all pure gaseous bodies, the rate of expansion for similar increase of temperature is similar: 100 measures of air, when heated from the freezing to the boiling point of water, suffer an increase in bulk = 37,5 parts at mean pressure. As heat increases the bulk of all bodies, it is obvious that change of temperature is constantly producing changes in their density or specific gravity, as may be easily demonstrated in fluids where there is freedom of motion among the particles. If I apply heat to the bottom of a vessel of water, the heated part expands and rises, while a cold or denser stratum occupies its place. In air, similar currents are continually produced, and the vibratory motion observed over chimney pots, and slated roofs which have been heated by the sun, depends upon this circumstance. The warm air rises, and its refracting power being less than that of the circumambient colder air, the currents are rendered visible by the distortion of objects viewed through them. There is only one strict exception to the general law of expansion by heat, and contraction by cold; this is in the case of water, which expands considerably when it approaches its freezing point.

Principle of Thermometers.

If we mix equal quantities of the same fluid at different temperatures, the cold portion will expand as much as the hot portion contracts, and the resulting temperature is the mean; so that it appears, that as much heat as is lost by the one portion is gained by the other. Upon this principle, thermometers are constructed. A common thermometer consists of a tube terminated at one end by a bulb, and closed at the other. The bulb and part of the tube are filled with a proper liquid, generally mercury, and a scale is applied, graduated into equal parts. Wherever this instrument is applied to bodies of the same temperature, the mercury, being similarly expanded, indicates the same degree of heat. In dividing the scale of a thermometer, the two fixed points usually resorted to are the freezing and boiling of water, which always take place at the same temperature, when under the same atmospheric pressure. The intermediate part of the scale is divided into any convenient number of degrees; and it is obvious, that all thermometers thus constructed will indicate the same degree of heat when exposed to the same temperature. In the centigrade thermometer, this space is divided into 100^0; the freezing of water being marked 0, the boiling point 100^0. In this country we use Fahrenheit's scale, of which the 0^0 is placed at 32^0 below the freezing of water; which, therefore, is marked 32^0, and the boiling point 212^0, the intermediate space being divided into 180^0. Another scale is Reaumur's; the freezing point is 0^0, the boiling point $= 80^0$. These are the principal thermometers used in Europe. Each degree of Fahrenheit's scale is equal to $\frac{4}{9}$ of a degree on Reaumur's; if, therefore, the number of degrees on Fahrenheit's scale, above or below the freezing of water, be multiplied by 4, and divided by 9, the quotient will be the corresponding degree of Reaumur.

Fahrenheit. Reaumur.

$$68^0 - 32^0 = 36 \times 4 = 144 \div 9 = 16^0$$
$$212^0 - 32^0 = 180 \times 4 = 720 \div 9 = 80^0$$

To reduce the degrees of Reaumur to those of Fahrenheit, they are to be multiplied by 9, and divided by 4.

Reaumur. Fahrenheit.

$$16^0 \times 9 = 144 \div 4 = 36^0 + 32^0 = 68$$
$$80 \times 9 = 720 \div 4 = 180 + 32 = 212$$

Every degree of Fahrenheit is equal to $\frac{5}{9}$ of a degree on the Centigrade scale; the reduction, therefore, is as follows.

Fahrenheit. Centigrade.

$$212 - 32 = 180 \times 5 = 900 \div 9 = 100^0$$

Centigrade. Fahrenheit.

$$100 \times 9 = 900 \div 5 = 180 + 32 = 212^0$$

Where a thermometer is intended to measure very low temperatures, spirit of wine is employed in its construction, as that fluid has never been frozen, whereas the low temperature at which it boils, renders it unfit for measuring high temperatures. Quicksilver will indicate 500^0, but freezes at -40^0. Air is sometimes resorted to as indicating very small

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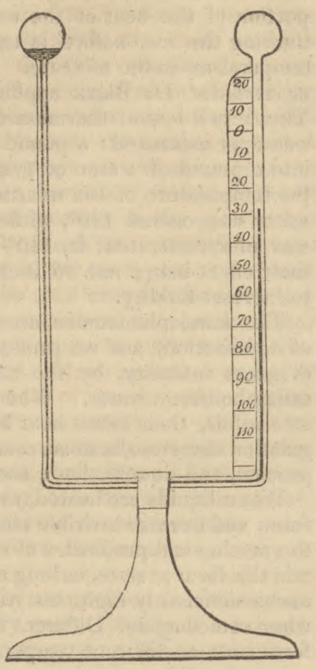
changes of temperature; and of air thermometers, that described by Professor Leslie,* under the name of the Differential Thermometer, is the best. It consists of two large glass bulbs containing air, united by a tube twice bent at right angles, containing coloured sulphuric acid. When a hot body approaches one of the bulbs, it drives the fluid towards the other. The great advantage of this instrument in delicate experiments is, that general changes of the atmosphere's temperature do not affect it, but it only indicates the difference of temperature between the two balls.

Differential Thermometer.



The relative quantities of heat which different bodies in the same state require to raise them to the same thermometric temperature, is called their specific heat, and those bodies which require most heat are said to have the greatest *capacity* for heat. That the quantity of heat in different bodies of the same temperature is different, was first shown by Dr Black, in his lectures at Glasgow, in 1762.

It has been stated as a proof of the accuracy of the thermometer, that equal volumes of the same fluid, at different temperatures, give the arithmetical mean, on mixture. Thus, the temperature of a pint of hot and a pint of cold water is, after mixture, as near as possible half-way between the extremes. The cold water being of a temperature of 50°, and the hot of 100°, the mixture raises the thermometer to 75°. But if a pint of quicksilver at 100° be mixed with a pint of water at 50°, the resulting temperature is not 75°, but 70°; so that the quicksilver has lost 30°, whereas the water has only gained 20°. Hence, it appears, that the capacity of mercury for heat is less than that of water; and if the *weight* of the two bodies be compared, which are as 13,3 to 1, their capacities will be to each other as 19 to 1.

In cases where the specific heat of bodies is to be ascertained, it is convenient that water should be the standard of comparison, or $= 1$. The following is a general formula for determining the specific heat of bodies, from the temperature resulting from the mixture of two bodies at unequal temperatures, whatever be their respective qualities. Multiply the weight of the water by the difference between its original temperature, and that of the mixture. Also, multiply the weight of the other liquid, by the difference between its temperature and that of the mixture; divide the first product by the second, and the quotient will express the specific heat of the other substance, that of water being $= 1$. Thus, 20 ounces of water at 105°, mixed with 12 ounces of spermaceti oil at 40°, produce a temperature of 90°. Therefore, multiply 20 by 15 (the difference between 105 and 90) $= 300$. And multiply 12 by 50 (the difference between 40 and 90) $= 600$. Then 300, $\div$ 600, $= \frac{1}{2}$, which is the specific heat of oil; that is, water being 1, oil is 0,5.

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Capacities of Bodies for Heat.

The capacities of bodies for heat have considerable influence upon the rate at which they are heated and cooled. Those bodies which are most slowly heated and cooled have generally the greatest capacity for heat. Thus, if equal quantities of water and quicksilver be placed at equal distances before the fire, the quicksilver will be more rapidly heated than the water, and the metal will cool most rapidly when carried to a cold place. Upon this principle, Professor Leslie ingeniously determined the specific heat of bodies, observing their relative times of cooling a certain number of degrees, comparatively with water, under similar circumstances.

The Calorimeter, invented by Lavoisier for determining the specific heat of bodies, is an inaccurate instrument.

The capacity of gases and vapours differs with the nature of the gas, and with its density. In gases dilatation produces cold, and compression excites heat. A thermometer suspended in the receiver of the air-pump sinks during exhaustion, and sudden compression of air produces heat sufficient to inflame tinder. In liquids, too, condensation diminishes capacity for heat; hence the mixture of spirit and water, and of oil of vitriol and water, evolves heat. The increased capacity which air acquires by rarefaction has its influence in modifying natural temperatures. The air, becoming rarer as it ascends, absorbs its own heat, and hence becomes cold in proportion as it recedes from the earth's surface: thus moisture, rain, or snow, are thrown down on the mountain tops.

When different bodies are exposed to the same source of heat, they suffer it to pass through them with very different degrees of velocity, or they have various conducting powers in regard to heat. Among solid bodies, metals are the best conductors. And silver, gold, and copper, are better conductors than platinum, iron, and lead. Next to the metals, we may, perhaps, place the diamond,—then glass,—then siliceous and hard stony bodies in general,—

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* *Experimental Inquiry into the Nature and Propagation of Heat*, by John Leslie. London, 1804, p. 9, &c.

then soft and porous earthy bodies, and wood,—and, lastly, down, feathers, wool, and other porous articles of clothing.

Liquids and gases are very imperfect conductors of heat, and heat is generally distributed through them by a change of specific gravity, as before stated.

If we apply heat to the upper surface of any fluid, it will with great difficulty make its way downwards. Count Rumford considered fluids as non-conductors of heat; but the more accurate researches of Dalton, Hope, Murray,* and Thomson,† have demonstrated that they do conduct, though very imperfectly. Experiments on the conducting power of air are complex and difficult, and the results hitherto obtained are unsatisfactory. They are interfered with by several circumstances presently to be noticed.

The different conducting powers of bodies is shown in the application of wooden handles to metallic vessels, or a stratum of ivory or wood is interposed between the hot vessel and the metal handle. The transfer of heat is thus prevented. Heat is confined by bad conductors; hence clothing for cold climates consists of woollen materials; hence, too, the walls of furnaces are composed of clay and sand. Confined air is a very bad conductor of heat; hence the advantage of double doors to furnaces, to prevent the escape of heat, and of a double wall, with an interposed stratum of air, to an ice house, which prevents the influx of heat from without. From the different conducting powers of bodies in respect to heat, arise the sensations of heat and cold experienced upon their application to our organs, though their thermometric temperature is similar. Good conductors occasion when touched a greater sensation of heat and cold than bad ones. Metal feels cold because it readily carries off the heat of the body; and we cannot touch a piece of metal immersed in air of a temperature moderate to our sense.

Latent Heat.

Heat has great influence on the forms or states of bodies. When we heat a solid, it becomes fluid or gaserous; and liquids are converted into aëriform bodies or vapours. Dr Black investigated this effect of heat with singular felicity, and his researches rank among the most admirable effects of experimental philosophy. ‡ During the liquefaction of bodies, a quantity of heat is absorbed, which is essential to the state of fluidity, and which does not increase the sensible or thermometric temperature. Consequently, if a cold solid body, and the same body hot and in a liquid state, be mixed in known proportions, the temperature after mixture will not be the proportional mean, as would be the case if both were liquid, but will fall short of it; much of the heat of the hotter body being consumed in rendering the colder solid *liquid*, before it produces any effect upon its *sensible temperature*. Equal parts of *water* at 32° and of *water* at 212° will produce on mixture a mean temperature of 122°. But equal parts of *ice* at 32° and of water at 212° will only produce (after the liquefaction of the ice) a temperature of 52°, the greater portion of the heat of the water being employed in thawing the ice, before it can produce any rise of temperature in the mixture. To heat thus *insensible* or *combined*, Dr Black applied the term *latent heat*. The actual loss of thermometric heat in these cases was thus estimated: a pound of ice at 32° was put into a pound of water at 172°; the ice melted, and the temperature of the mixture was 32°. Here the water was cooled 140°, while the *temperature* of ice was unaltered; that is, 140° of heat disappeared,—their effect being not to increase temperature, but to increase fluidity.

The same phenomena are observable in all cases of liquefaction, and we produce artificial cold, often of great intensity, by the rapid solution of certain saline bodies in water. When fluids are converted into solids, their latent heat becomes sensible; congelation therefore is to surrounding bodies a heating process, and liquefaction a cooling process.

When liquids are heated, they acquire the gaseous form, and become invisible elastic fluids, possessed of the mechanical properties of common air. They retain this form or state, as long as their temperature remains sufficiently high, but reassume the solid form when cooled again. Different fluids pass into the aëriform state at different temperatures, or their boiling points are different; they are also regulated by the density of the atmosphere. If we diminish atmospheric pressure, we lower the boiling point. When the barometer is at 28 inches, water will boil at a lower temperature than when it is at 31 inches. Water under mean atmospheric pressure boils at 212°. At the top of Mont Blanc, Saussure found that it boiled at 187°, so that the heights of mountains, and even of buildings, may be calculated by reference to the temperature at which water boils upon their summits. The Reverend Mr Wollaston has lately described to the Royal Society, the method of constructing a thermometer of extreme delicacy, applicable to these purposes. In the vacuum of an air-pump, fluids boil at temperatures considerably below their ordinary boiling points.

The conversion of a liquid into vapour, is always attended with great loss of thermometric heat, and, as liquids may be regarded as compounds of solids and heat, so vapours may be considered as consisting of a similar combination of heat with liquids; in other words, a great quantity of heat becomes latent during the formation of vapour. This is easily illustrated by immersing a thermometer into a vessel of water placed over a lamp. The quicksilver rises to 212°, the water then boils, and although the source of heat remains, neither the water nor the steam acquire a higher temperature than 212°; the heat then becomes latent, and is consumed in the formation of steam.

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* *System of Chemistry*, Vol. I.

† *System of Chemistry*, Vol. I.

‡ Black's *Lectures*, edited by John Robison, LL.D. Edinburgh, 1803.

To ascertain the absolute loss of thermometric heat in this case, Dr Black * instituted the following experiments: He noted the time required to raise a certain quantity of water to its boiling point; he then kept up the same heat till the whole was evaporated, and marked the time consumed by the whole process; it was thus computed to what height the temperature would have risen, supposing the rise to have gone on above 212°, in the same ratio as below it, and as the temperature of the steam was the same as that of the water, it was fairly inferred that all the heat above 212° was essential to the constitution of aqueous vapour. Dr Black estimated this quantity at about 810°, that is, the same quantity of heat which is required for the total evaporation of boiling water at 212° would be sufficient to raise the water 810° above its boiling point, or to 1022° had it continued in the liquid state. There are other means of ascertaining the latent heat of steam, which lead us to place it between 900° and 1000°.

When steam is again condensed, or when vapours reassume the liquid state, their latent heat becomes sensible, and in this way it is obvious that a small quantity of steam will, during its condensation, communicate heat sufficient to boil a large quantity of water.

The cold produced by evaporation is, under certain circumstances, very great. Spirit of wine and ether, which readily evaporate, produce considerable cold during that process. Upon this principle, wine coolers and similar porous vessels, refrigerate the fluids they contain; and thus, by accelerating the evaporation of water, by exposing it under an exhausted receiver, containing bodies that quickly absorb its vapour, Professor Leslie has contrived to effect its congelation; the heat required for the conversion of one portion of the water into vapour being taken from the other portion, which is thus reduced to ice.

The heat given off by steam during its condensation, is often advantageously applied to warming buildings, and is at once safe, salubrious, and economical. In many natural operations the conversion of water into vapour, and the condensation of vapour in the form of dew and rain, is a process of the utmost importance, and tends considerably to the equalization of temperature over the globe.

Supposed Cause of Heat.

Nothing is known of the nature or cause of heat. It has been by some considered as a peculiar fluid, to which the term *Caloric* has been applied; and many phenomena are in favour of the existence of such a fluid. By others, the phenomena above described have been referred to a *vibratory motion* of the particles of matter, varying in velocity with the perceived intensity of the heat. In fluids and gases the particles are conceived to have a motion round their own axis. Temperature, therefore, would increase with the velocity of the vibrations, and increase of capacity would be produced by the motion being performed in greater space. The loss of temperature during the change of solids into liquids and gases, would depend upon loss of *vibratory* motion, in consequence of the acquired *rotatory* motion.

Upon the other hypothesis, *temperature* is referred to the quantity of *caloric* present; and the loss of temperature which happens when bodies change their state, depends upon the chemical combination of the caloric with the solid in the case of liquefaction, and with the liquid in the case of conversion into the aëriform state. †

Electricity.

If a piece of sealing-wax and of dry warm flannel be rubbed against each other, they both become capable of attracting and repelling light bodies. Glass rubbed upon silk exhibits the same phenomena. In these cases the bodies are said to be *electrically excited*. If two pith-balls be electrified by touching them with the sealing-wax or with the flannel, they repel each other; but if one pith-ball be electrified by the wax and the other by the flannel, they attract each other. The same applies to the glass and silk; it shows a difference in the electricities of the different bodies; and the experiment leads to the conclusion, that bodies similarly electrified repel each other, but that, when dissimilarly electrified, they attract each other.

If one ball be electrified by sealing-wax rubbed by flannel, and another by silk rubbed with glass, those balls will repel each other; which proves, that the electricity of the silk is the same as that of the sealing-wax. But if one ball be electrified by the sealing-wax and the other by the glass, they then attract each other, showing that they are oppositely electrified.

Different Kinds of Electricity.

The terms vitreous and resinous electricity were applied to these two phenomena; but Franklin, observing that the same electricity was not inherent in the same body, but that glass sometimes exhibited the same phenomena as wax, and *vice versa*, adopted another term; and, instead of regarding the phenomena as dependent upon two electric fluids, referred them to the presence of one fluid, in excess in some cases, and in deficiency in others. To represent these states, he used the terms plus and minus, positive and negative. When glass is rubbed with silk, a portion of electricity leaves the silk, and enters the glass. It becomes positive, therefore, and the silk negative; but when sealing-wax is rubbed with flannel, the wax loses and the flannel gains. The former, therefore, is negative, the latter positive. All bodies in nature are thus regarded as containing the electric fluid, and, when its equilibrium is disturbed, they exhibit the phenomena just described.

Very delicate pith-balls, or stripes of gold leaf, are usually employed in ascertaining the presence of electricity; and, by the way in which their divergence is affected by glass or sealing-wax, the kind or

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* *Lectures*, pp. 145, *et seq.*—Dr Black's *Researches on the Latent Heat of Steam*, led Mr Watt to his great improvement of the steam-engine, of which an account is given in the *Lectures*, page 184.

† See Davy's *Elements of Chemical Philosophy*.

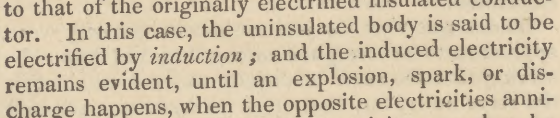
state of electricity is judged of. When properly suspended or mounted for delicate experiments, they form an electrometer. A considerable improvement in the insulation of the gold leaves has been introduced by the late Mr Singer, and is described in his *Elements of Electricity*. London, 1814.

Some bodies suffer electricity to pass through their substance, and are called *conductors*. Others only receive it upon the spot touched, and are called *nonconductors*. The former do not, in general, become electric by friction, and are called *nonelectrics*. The latter, on the contrary, are *electrics*, or acquire electricity by friction. They are also called *insulators*. The metals are all conductors; glass, sulphur, and resins, are nonconductors. Water, damp wood, spirit of wine, and some oils, are imperfect conductors.

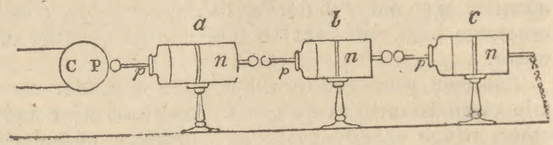
There are many substances which show signs of electricity when heated, as the tourmalin, topaz, diamond, boracite, &c.; and in these bodies the different surfaces exhibit different electrical states. Whenever one part of a body, or system of bodies, is positive, another part is invariably negative; and these opposite electrical states are always such as exactly to neutralize each other. Thus, in the common electrical machine, one conductor receives the electricity of the glass cylinder, and the other that of the silk rubber, and the former conductor is positive and the latter negative; but if they be connected, all electrical phenomena cease.

If an insulated conductor be electrified, and an uninsulated conductor be opposed to it, there being between the two a thin stratum of air, glass, or other nonconductor, the uninsulated conductor, under such circumstances, acquires an opposite electrical state to that of the originally electrified insulated conductor. In this case, the uninsulated body is said to be electrified by *induction*; and the induced electricity remains evident, until an explosion, spark, or discharge happens, when the opposite electricities annihilate each other. Induced electricity may thus be exhibited through a long series of insulated conductors, provided the last of the series be communicated with the earth.

Thus, in the following diagram, A may represent the positive conductor of the electrical machine. B, C, and D, three insulated conductors, placed at a little distance from each other. D having a chain touching the ground, then the balls 1, being positive, will attract the balls 2, which are rendered negative by induction. Under these circumstances, each of the conductors becomes polar, and the balls 3 are positive, while 4 are negative, 5 positive, 6 negative, &c. The central points of the conductors, B, C, D, are neutral. When these opposite electrical states have arrived at a certain intensity, sparks pass between the different conductors, and the electrical phenomena cease.



Upon the principle of induction it is that the accumulation of electricity in the Leyden phial is effected. It consists of a thin glass jar, coated internally and externally with tinfoil to within a short distance of its mouth. When the inner surface is rendered positive by union with the conductor of the electrical machine, the exterior becomes negative by induction. When the inner and outer surfaces are united by a conductor, all electrical accumulation is annihilated by a spark, and the two opposite states are found to have been precisely equivalent. If one Leyden jar be insulated with its internal surface connected with the positive conductor, another jar may be charged from its exterior coating; and if this second jar be insulated, a third may be charged from its exterior coating, and so on for any number of jars, provided always that the exterior coating of the last jar be connected with the ground. In this case, a polar arrangement, similar to that of the conductors just described, will have been formed, glass being the medium of induction instead of air.



Let CP be the positive conductor of the electrical machine, and *a*, *b*, *c*, three insulated Leyden phials, the outer coating of *c* being connected with the ground; it is then obvious, that there will be the same polar state as in the conductors just noticed; that the insides of *a*, *b*, and *c*, will be positive, and the outsides negative; and that, consequently, on removing the jars from each other, they will all be similarly charged, and that if the three inner surfaces *p*, *p*, *p*, and the three outer surfaces *n*, *n*, *n*, be united, the whole may be discharged as one jar.

Electricians employ the term *quantity* to indicate the absolute quantity of electric power in any body, and the term *intensity* to signify its power of passing through a certain stratum of air or other ill-conducting medium.

If we suppose a charged Leyden phial to furnish a spark when discharged of one inch in length, we should find that another uncharged Leyden phial, the inner and outer coating of which were communicated with those of the former, would, upon the same quantity of electricity being thrown in, reduce the length of the spark to half an inch; here, the *quantity* of electricity remaining the same, its *intensity* is diminished by one-half, by its distribution over the larger surface.

There are many other sources of electricity than those just noticed. Whenever bodies change their forms, their electrical states are also altered. Thus the conversion of water into vapour, and the congelation of melted resins and sulphur, are processes in which electricity is also rendered sensible.

When an insulated plate of zinc is brought into contact with one of copper or silver, it is found,

after removal, to be positively electrical, and the silver or copper is left in the opposite state. If the nerve of a recently killed frog be attached to a silver probe, and a piece of zinc be brought into the contact of the muscular parts of the animal, violent convulsions are produced every time the metals thus connected are made to touch each other.

If a piece of zinc be placed upon the tongue, and a piece of silver under it, a peculiar sensation will be perceived every time the two metals are made to touch.

In these cases the chemical properties of the metals are observed to be affected. If a silver and a zinc wire be put into a wine glass full of dilute sulphuric acid, the zinc wire only will evolve gas; but upon bringing the two wires in contact with each other, the silver will also copiously produce air bubbles.

If a number of alternations be made of copper or silver leaf, zinc leaf, and thin paper, the electricity excited by the contact of the metals will be rendered evident to the common electrometer. Also, if plates of zinc and copper be regularly arranged, with moistened flannel between each pair of plates, we shall observe that, having made 50 or 60 such alternations, the same effect will be produced, and that the zinc plate will give a positive, and the copper extreme a negative charge to the gold leaf electrometer.

If the same arrangement be made with strong brine, or a weak acid, it will be found, on bringing a wire communicating with the last copper plate into contact with the first zinc plate, that a spark is perceptible, and also a slight shock, provided the number of alternations be sufficiently numerous. This is the Voltaic apparatus.

On immersing the wires from the extremes of this apparatus into water, it is found that the fluid suffers decomposition, and that oxygen gas is liberated at the positive wire or pole, and hydrogen gas at the negative pole.

All other substances are decomposed with similar phenomena, the inflammable element being disengaged at the negatively electrical surface; hence it would appear, upon the principle of similarly electrified bodies repelling each other, and dissimilarly electrified bodies attracting each other, that the inherent or natural electrical state of the inflammable substances is *positive*, for they are attracted by the *negative* or oppositely electrified pole; while the bodies called supporters of combustion, or acidifying principles, are attracted by the positive pole, and, therefore, may be considered as possessed of the negative power.

All bodies which exert powerful chemical agencies upon each other, when freedom of motion is given to their particles, render each other oppositely electrical when acting as masses. Hence Sir H. Davy, the great and successful investigator of this branch of chemical philosophy, has supposed that electrical and chemical phenomena, though in themselves quite distinct, may be dependent upon one and the same power, acting in the former case upon masses of matter, in the other upon its particles.

We refer to the article Electricity for the theory of the Voltaic Pile; a subject involved in considerable difficulty. In it the *quantity* of electricity is always increased by extending the surface of the plates, while the *intensity* rapidly augments with the increase of the number of alternations. Both quantity and intensity, in this instance, are greatly influenced by the chemical action of the fluid upon the plates; the acid bodies, as possessing highly opposite states to those of the metals, are most efficacious; and, in experiments made with the great Voltaic apparatus at the Royal Institution, it has been found that 120 plates, rendered active by a mixture of one part of nitric acid, and three of water, produced effects equal to 480 plates, rendered active by 1 part of nitric acid, and 15 of water.

Supposed Cause of Electrical Phenomena.

We have as yet no plausible hypothesis concerning the *cause* of electrical phenomena, though the subject has engaged the attention of the most eminent philosophers of Europe. They have been by some referred to the presence of a peculiar fluid existing in all matter, and exhibiting itself by the phenomena which have been described, whenever its equilibrium is disturbed, presenting negative and positive electricity when deficient and when redundant. Others have plausibly argued for the presence of two fluids, distinct from each other. Others have considered the effects as referable to peculiar exertions of the attractive powers of matter, and have regarded the existence of any distinct fluid or form of matter to be as unnecessary to the explanation of the phenomena, as it is in the question concerning the cause of gravitation.

When the flame of a candle is placed between a positive and negative surface, it is urged towards the latter; a circumstance which has been explained upon the supposition of a current of electrical matter passing from the positive to the negative pole;—indeed, it has been considered as demonstrating the existence of such a current of matter.* But if the flame of phosphorus be substituted for that of a candle, it takes an opposite direction; and, instead of being attracted towards the negative, it bends to the positive surface. It has been shown that inflammable bodies are always attracted by negative surfaces, and acid bodies, and those in which the supporters of combustion prevail are attracted by positive surfaces. Hence the flame of the candle throwing off carbon, is directed to the negative pole, while that of phosphorus goes to the positive, consistently with the ordinary laws of electro-chemical attraction.

There are many experiments which sanction the idea that electricity is "an exhibition of attractive powers acting in certain combinations." If we discharge a Leyden phial through a quire of paper, the perforation is equally burred upon both sides, and not

* Cuthbertson's *Practical Electricity and Galvanism*, P. 104. London, 1807.

upon the negative side only, as would have been the case if any material body had gone through in that direction. The power seems to have come from the centre of the paper, as if one-half of the quire had been attracted by the positive, and the other by the negative surface.

In this outline of the history of the powers of matter, an attempt has been made to draw together, under one point of view, the principal facts required to render the subsequent parts of this article intelligible. It has been necessary, on many occasions, to refer to the more extended discussions in the body of this work; and, under the heads CRYSTALLIZATION, CHEMICAL AFFINITY, HEAT, ELECTRICITY, and GALVANISM, the reader will find ample materials for the completion of this sketch.

PART II.

Of the substances belonging to our globe, some are of so subtile a nature as to require minute and delicate investigation to demonstrate their existence; they can neither be confined nor submitted to the usual modes of examination, and are known only in their states of motion as acting upon our senses, or as producing changes in the more gross forms of matter. They have been included under the general term of ETHERIAL OR IMPONDERABLE MATTER, which, as it produces different phenomena, must be considered as differing either in its nature or affections. Respecting the nature of these phenomena, two opinions have been entertained, and each ably supported. It has been supposed by Huygens and Descartes, that they arise from vibrations of a rare elastic medium which fills space; while Newton has considered them as resulting from emanations of particles of matter.

The other forms of matter are tangible and ponderable, and, therefore, easily susceptible of accurate examination; they may be considered as resulting from the mutual agencies of heat and attraction, and are comprehended under the three classes of *Solids*, *Liquids*, and *Gases*.

RADIANT MATTER.

Properties of the Solar Rays.

In considering the phenomena of radiant matter as connected with chemistry, its mechanical properties must often be necessarily dwelt upon, as importantly connected with the changes it effects in the composition of bodies. These, however, cannot be minutely entered into in this place; they will be found discussed in the body of the work. (See OPTICS, &c.) Such points of the inquiry will only be alluded to as are absolutely necessary to render the subject intelligible to the Chemist. That a sunbeam, in passing through a dense medium, gives rise to a series of brilliant tints similar to those of the rainbow, was known in the earliest ages, but it required the sagacity of Newton to develope the cause of the phenomenon. He proved, that *light* consists of rays differing from each other in their relative refrangibilities; and guided by their colour,—considered their number as seven:—red, orange, yellow, green, blue, indigo, and violet. Of these rays, the red being least refrangible, falls nearest that spot which the ray would have passed to, had it not been refracted, while the violet ray being most refrangible, is thrown to the greatest distance,—the intermediate rays possess mean degrees of refrangibility. These differently coloured rays are not susceptible of further decomposition, by any number of refractions, but when they are collected into a focus they reproduce white light. Upon these phenomena is founded the Newtonian theory of colours.

If a solar beam be refracted by a prism, and the coloured image received upon a sheet of paper, it will be found, on moving the hand gently through it, that there is an evident increase of temperature towards the red ray. This fact seems to have been first noticed by Dr Hutton (*Dissertation on Light and Heat*, p. 39); but it is to Dr Herschel (*Philos. Trans.* 1800) that we are indebted for a full investigation of the subject. If the coloured rays be thrown successively upon delicate thermometers, it will be found, that if the heating power of the violet rays be considered $= 16$, that of the green rays will be $= 26$, and of the red $= 55$. These circumstances suggested the possibility of the heating power of the spectrum extending beyond the red ray; and on applying a thermometer just out of the red ray, and beyond the limits of the visible spectrum, this was found to be the case. A thermometer in the red ray rose 7^0 in ten minutes, but just beyond the red ray the rise was $= 9^0$. It is evident, therefore, that, independent of the illuminating rays, there are others which produce increase of temperature, and these, from their increase towards the red ray, and from the spot which they principally occupy in the refracted congeries, are possessed of less refrangibility than the visible rays.

That these calorific rays are susceptibile of refraction and reflection, is proved by the intense heat produced when the solar rays are concentrated into a focus by a lens, or by a concave mirror.

The radiant matter emitted by terrestrial bodies at high temperatures, agrees in many of its properties with that constituting the solar rays, but in others it presents material differences. The investigation of this subject constitutes a beautiful department of philosophic inquiry. The effect we perceive in approaching a fire chiefly results from radiation; and is little connected with the immediate conducting power of the air: and if a concave *metallic* mirror be held opposite the fire, a heating and luminous focus will be obtained. The affections of terrestrial radiant matter are best demonstrated by employing two concave mirrors of planished tin or plated copper, placed at a distance of about 10 feet asunder. (Pictet *Essais de Phisique*.) Under these circumstances, when a thermometer is in the focus of one of the mirrors, it will be found sensible to the effects of a heated body placed in the focus of the opposed mirror; and that the effect is produced by reflection, and not by mere direct radiation, is proved, either by drawing the thermometer out of the focus to-

wards the opposed mirror, or by placing a screen between the thermometer and its mirror, when diminution of temperature is in either case indicated.

If the flame of a candle be placed in the focus of one mirror, a heating and luminous focus is obtained from the other: but if a plate of glass be now interposed between the two mirrors, the rays of heat are arrested, while those of light freely passing through the glass, are collected, as usual, in the opposite focus. This, therefore, proves a difference between solar and terrestrial heat; the rays of the former pass through glass without heating it; the rays of the latter are stopped by glass, and it becomes hot when opposed to them. (Scheele's *Experiments on Air and Fire.*)

In these experiments upon the radiation of terrestrial heat, the temperature excited by the radiant matter appears always relative to that of the heated or radiating body; and if we assume that all bodies are constantly throwing off radiant matter, the effects of temperature which it produced when condensed or collected into a focus by a concave mirror will bear a relation to the source; for the particles may be conceived to move with such velocity as not to be affected by circumjacent bodies, or by the circumambient air. Thus, white hot iron produces a greater effect upon the focal thermometer than that which is only red hot, and red hot iron causes a greater effect than hot water—a body of the same temperature, as the thermometer causes no change in it, but cold bodies produce an effect of cold, because the particles which they radiate, when stopped by impinging upon the thermometer bulb, are of a lower temperature. Radiation has by some been accounted for upon the idea of the heated body producing undulations in the air, something analogous to those waves excited by sonorous bodies; but *matter in motion* may rather be regarded as the cause of the effect, and the different phenomena of prismatic refraction and of solar and terrestrial radiation can only be explained upon such an hypothesis.

Radiation goes on in all elastic media, and in the Torricellian and air pump vacuum.

Absorbing and Reflecting Powers of different Colours and Surfaces.

It has long been known in regard to solar rays, that their heating effect depends much upon the colour of the surfaces upon which they impinge, and that black and dark bodies are more heated than those which are white or of light tints, circumstances dependent upon absorption and reflection. Professor Leslie has shown that the phenomena of terrestrial radiation are connected with the nature of the radiating surface; and that those surfaces which are the best radiators of this heat, are also gifted with the greatest absorbing power. (Leslie *on Heat.*)

Unmetallic and unpolished surfaces are the best radiators, and also the best receivers of radiant heat; while polished metallic substances are the worst radiators, and have the lowest absorbing powers. In the experiments with the metallic mirrors, the whole nearly of the heat is reflected, and the mirror itself does not become warm; but if it be coated with any unpolished and especially unmetallic coating, as with paper, or paint, the radiation is then scarcely perceptible, and the mirror becomes hot from the absorption of the radiant matter.

In Professor Leslie's experiments it was found, that a clean metallic surface produced an effect = 12 upon the thermometer. When covered with a thin coat of glue, its radiating power was so far increased as to produce an effect = 80; and, on covering it with lamp-black, it became = 100.

In these cases of radiation the *colour* of the surface does not interfere, and the different effects must be referred to the mechanical structure of the radiating surface. White paper and lamp-black produce nearly the same effects, and paper coloured blue, red, yellow, and green, does not differ in radiating power from that which is white, provided the colour produces no change of texture in the paper.

The connection of the receptive with the radiating power is made obvious by coating the bulbs of thermometers with different substances. Thus, the effect of radiant heat upon a thermometer bulb covered with a thin coating of lamp-black being = 100; when the bulb is covered with silver-leaf the effect is only = 12.

Radiant matter possesses considerable influence over the chemical energies of bodies. If equal volumes of the gases called chlorine and hydrogen be exposed in a dark room, they slowly combine, and produce muriatic acid gas; but if they be exposed to the direct rays of the sun, the combination is very rapid, and often accompanied by an explosion.

Chlorine and carbonic oxide have scarcely any tendency to combine even at high temperature when light is excluded, but exposed to the solar rays they enter into chemical union. Chlorine has little action upon water, unless exposed to light, and, in that case, the water which consists of oxygen and hydrogen is decomposed. The hydrogen unites with the chlorine to produce muriatic acid, and the oxygen is evolved and combined in a gaseous form.

These, and numerous other similar cases which might be adduced, show that radiant matter influences the chemical energies of bodies, independent of its heating powers. Scheele (*Experiments on Air and Fire*, p. 78, &c.) was the first who entered upon this curious investigation; and many important facts connected with it have been more lately ascertained by Ritter, Wollaston, and Davy. Scheele threw the prismatic spectrum upon a sheet of paper, moistened with a solution of nitrate of silver, a salt quickly decomposed by the agency of light. In the blue and violet rays the silver was soon reduced, producing a blackness upon the paper, but in the red ray scarcely any similar effect was observed. Wollaston and Ritter discovered that these chemical changes were most rapidly effected in the space which bounds the violet ray, and which is out of the visible spectrum.

It has thus been ascertained, that the solar beams are refrangible into three distinct kinds of rays,—the calorific, or heating rays; the colorific rays which produce colour; the decomposing rays, or those which have a tendency to interfere with the chemical constitution of bodies.

In the prismatic spectrum these three sets of rays are imperfectly separated, and arranged according to their respective refrangibilities. The heating rays are the least refrangible, the colorific rays are pos-

sessed of more refrangibility, and the chemical, or, as some have called them, the deoxidizing rays, are the most refrangible.

Sir H. Davy has observed, that certain metallic oxides, when exposed to the violet extremity of the prismatic spectrum, undergo a change similar to that which would have been produced by exposure to a current of hydrogen; and that, when exposed to the red rays, they acquire a tendency to absorb oxygen. (*Elements of Chemical Philosophy.*) In such general facts, he traces an analogy between the effects of the solar beam, and the agencies of electricity. In the Voltaic circuit, the maximum of heat is at the positive pole, where the power of combining with oxygen is also given to bodies; the agency of rendering bodies inflammable is exerted at the opposite surface, and similar chemical effects are produced by negative electricity, and by the most refrangible rays, and by positive electricity, and the rays which are least refrangible.

PART III.

Having thus rapidly explained the laws of Attraction, Heat, and Electricity, and the phenomena exhibited by Radiant Matter, we proceed to the Elementary or Undecompounded Bodies and their mutual combinations. These bodies are between fifty and sixty in number; four are gaseous, and the remainder solids: there are no simple liquids. They may be arranged under three heads:

1. Acidifying Supporters of Combustion.
2. Acidifiable Combustibles.
3. Metals.

The first division includes three substances.

1. Oxygen.
2. Chlorine.
3. Iodine.

1. *Oxygen.* (From οξυς γειναμει, producer of acids.)

This elementary gaseous body may be obtained by heating to redness, in a glass retort, the salt called Oxymuriate of Potash, 100 grains of which yield about 100 cubical inches; it may be collected over water in the hydro-pneumatic apparatus. (See CHEMISTRY, *Encycl.*) It is also given off from black oxide of manganese, red oxide of lead, or nitre when exposed to a red heat. It was discovered by Dr Priestley in the year 1774. (Priestley *on Air*, Vol. II. 154.)

Oxygen gas is insipid, colourless, and inodorous; its specific gravity is 15, hydrogen being assumed = 1. 100 cubical inches at mean temperature and pressure weigh 33.75 grains It is a powerful supporter of respiration and combustion. A small animal confined in oxygen gas, lives thrice as long as when confined in the same bulk of common air. A lighted taper, or a burning piece of sulphur, or phosphorus introduced into this gas, is very rapidly consumed, with intense ignition.

The phenomena of combustion were referred by Stahl and his associates, to a peculiar principle which they called *phlogiston:* it was supposed to exist in all combustibles, and combustion was said to depend upon its separation; but this explanation was absurdly at variance with the well known fact, that bodies during combustion increase in weight.

After the discovery of oxygen gas, it was adopted by Lavoisier as the universal supporter of combustion. The basis of the gas was supposed to unite to the combustible, and the heat and light which it before contained in the gaseous state, were said to be evolved in the form of flame. But in this case, several requisites are not fulfilled; the light depends upon the combustible, and not upon the quantity of oxygen consumed; and there are very numerous instances of combustion in which oxygen, instead of being solidified, becomes gaseous during the operation; and, lastly, in others, no oxygen whatever is present. Combustion, therefore, cannot be regarded as dependent upon any peculiar principle or form of matter, but must be considered as a general result of intense chemical action. It may be connected with the electrical energies of bodies; for all bodies which powerfully act upon each other, are in the opposite electrical states of positive and negative; and the evolution of heat and light may depend upon the annihilation of these opposite states, which happens whenever they combine.

2. *Chlorine.* (From χλωρος, greenish yellow.)

To obtain this gas, a mixture of black oxide of manganese and muriatic acid may be heated over a lamp in a glass retort. It is soon copiously evolved, and may be conveniently collected over warm water; as it is absorbed by cold water, it cannot be long retained over that fluid.

It may also be procured in the same way from a mixture of 8 parts of common salt, 3 of black oxide of manganese, 4 of water, and 5 of sulphuric acid.

Chlorine was discovered by Scheele in 1774; it was called by him dephlogisticated muriatic acid. The term oxymuriatic acid was afterwards applied to it by the French chemists.

Chlorine is a permanently elastic gaseous fluid; it has a pungent and disagreeable smell, and is highly injurious when respired. even largely diluted with atmospheric air. Its colour is greenish yellow.

The specific gravity of chlorine, composed with hydrogen, is as 33,5 to 1; 101 cubic inches weigh 75,375 grains. At the temperature of 60°, water dissolves two volumes of chlorine. The solution is of a pale yellow colour, has an astringent nauseous taste, and destroys vegetable colours, though the gas itself, when perfectly free from moisture, has scarcely any action upon them. When a burning taper is immersed in a jar of chlorine, the brilliancy of the flame is much impaired, it becomes red, throws off much charcoal, and is soon extinguished. Many bodies, such as phosphorus and several of the metals, are spontaneously ignited by chlorine, and burn in it with much brilliancy. In these cases, binary compounds result, some of which, like those of oxygen, are possessed of acid properties. Others are not acid, and

such compounds with oxygen, being called *oxides*, those which chlorine forms may be termed *chlorides*. *

Chlorine was once regarded as composed of oxygen and muriatic acid, a fallacy arising from the presence of water, and which will be rendered more intelligible under the head *Muriatic Acid.* (See Davy's Paper, *Phil. Trans.* 1811.)

Chlorine and oxygen unite in two proportions, forming an oxide and an acid.

Oxide of Chlorine or *Euchlorine*, so called by its discoverer, Sir H. Davy (*Phil. Trans.* 1815), from its very deep colour, may be obtained as follows. Upon 10 or 12 grains of the salt called oxymuriate of potash, drop a small quantity of sulphuric acid, and stir the mixture with a platinum knife, having so adjusted the relative quantities of salt and acid, that they may form together a yellow powder. Put this into a very small retort or bent tube, and by a water bath, apply a temperature of 150°. Euchlorine will pass off, and may be collected over quicksilver in small jars, or tubes. The smell of this gas somewhat resembles that of chlorine, but is much less irritating and disagreeable. Its taste is astringent, and not at all acid. When gently heated, it is decomposed with explosion and expansion,—two volumes are enlarged into three, of which two consist of oxygen, and one of chlorine; it is therefore composed of 33,5 parts by weight of chlorine combined with 30 of oxygen.

Chloric acid. In the compound which has been thus called by its discoverer M. Gay-Lussac (*Annales de Chimie*, tom. 91, p. 108), the relative proportions of chlorine to oxygen are to each other as 33,5 to 37,5; but it is a compound which cannot exist, independent of water or some base, and, therefore, may be compared to the *sulphuric acid.* It may be prepared by passing a current of chlorine, through a mixture of oxide of silver † and water. Chloride of silver is produced, which is insoluble, and may be separated by filtration. The excess of chlorine which the filtered liquor contains is separable by heat, and the chloric acid dissolved in water remains. It is a sour colourless liquid, producing peculiar compounds afterwards to be described. It forms no precipitate in any metallic solution. Its compounds may be called *chlorates.* The most remarkable of them have been long known under the name of *Oxymuriates.*

3. *Iodine.* (From ιώδης, *violaceus.*)

Iodine is procured by the following process: Lixiviate powdered kelp with cold water. Evaporate the lixivium till a pellicle forms, and set aside to crystallize. Evaporate the mother liquor nearly to dryness, and pour upon the mass half its weight of sulphuric acid. Apply a gentle heat to this mixture in a glass alembic; fumes of a violet colour arise and condense in the form of opaque crystals, having a metallic lustre.

This body was discovered in 1812 by M. Courtois of Paris. Vauquelin (*Annales de Chimie*, t. 90), Gay-Lussac (*ib.* 91), and Davy (*Phil. Trans.* 1814), have successfully investigated its properties.

Iodine has a bluish black colour; its lustre is metallic. It is soft and friable. Its specific gravity = 4.946. It produces a yellow stain upon the skin. Its smell resembles that of diluted chlorine; its taste acid. It is extremely volatile, and, at a temperature between 60° and 80°, produces a violet vapour. At 120° or 130° it rises more rapidly. At 220° it fuses, and produces copious violet-coloured fumes, which condense in brilliant plates, and acute octoëdrons. Like chlorine and oxygen, it is electro-negative; and therefore attracted by the positive surface of the Voltaic pile.

Oxiodic acid (Davy, *Phil. Trans.* 1815). This compound of oxygen and iodine cannot be obtained directly, for those bodies exert no mutual action. It is procured by acting upon euchlorine by iodine. A liquid is formed, which consists of chloriodic and oxiodic acids. The former is separable by a gentle heat, the latter remains as a white, semitransparent, sour, and inodorous body, very soluble in water. It consists of 117 iodine, 37,5 oxygen.

Chloriodic acid is easily obtained by the direct action of chlorine upon iodine. They unite and form crystals of a deep orange colour, deliquescent, and easily fusible and soluble. The solution is sour. This compound contains 117 iodine, 33,5 chlorine.

The second division of undecompounded substances includes those which are acidifiable and combustible. These are,

1. Hydrogen.
2. Nitrogen.
3. Sulphur.
4. Phosphorus.
5. Carbon.
6. Boron.

1. *Hydrogen.* (From ὕδωρ, &c. *the base of water.*)

Hydrogen was first duly examined by Mr Cavendish (*Phil. Trans.* Vol. 56). It is obtained by acting upon dilute sulphuric acid by zinc filings, and by other methods presently to be noticed.

It is an aëriform fluid, not absorbable by water. It has no taste, a slightly disagreeable smell, and may be respired for a short time, though it is instantly fatal to small animals. It is the lightest body known; and we therefore conveniently assume it as unity in speaking of the specific gravity of gases, as well as in referring to the proportions in which bodies combine. 100 cubic inches weigh at mean temperature and pressure 2,25 grains. It is inflamma-

* Sir H. Davy designates these compounds by the terminations *ane* and *ana*.

† Prepared by precipitating the solution of nitrate of silver with lime-water.

ble, and extinguishes flame. When pure, it burns quietly with a lambent blue flame at the surface in contact with air, but if mixed with thrice its volume of air, it burns rapidly, and with detonation.

Hydrogen and Oxygen.—When two volumes of hydrogen gas are mixed with one volume of oxygen gas, and the mixture inflamed in a proper apparatus by the electric spark, the gases totally disappear, and the interior of the vessel is covered with drops of pure water, equal in weight to that of the gases consumed.

If pure water be exposed to the action of Voltaic electricity, it is resolved into two volumes of hydrogen, disengaged at the negative pole, and one volume of oxygen, disengaged at the positive pole; so that water is thus proved by synthesis, and by analysis, to consist of two volumes of hydrogen, combined with one volume of oxygen. The specific gravity of hydrogen compared with oxygen, is as 1 to 15; therefore the component parts of water by weight are,

1 hydrogen,
7,5 oxygen.

$$\left.\begin{array}{r}\text{Representative}\\ \text{number of water}\end{array}\right\} = 8.5$$

or thus,

H.	O.	water
1	7,5	8,5.

The mechanical and other properties of water are discussed at length in the body of the work. Its composition was discovered by Mr Cavendish in 1781.

Hydrogen and Chlorine.—When equal volumes of these gases are mixed, and exposed to light, they combine, and produce a sour compound, commonly called *muriatic acid gas*; or, in conformity to more modern nomenclature, *hydrochloric acid gas.* The best mode of showing the composition of muriatic acid, is to introduce into a small but strong glass vessel a mixture of the two gases, and to inflame them by the electric spark; no change of volume ensues, and muriatic gas results. This compound may be decomposed by the action of several of the metals. Potassium, for instance, absorbs the chlorine, and the hydrogen is evolved; and muriatic acid gas thus affords half its volume of hydrogen. As the specific gravity of hydrogen to chlorine is as 1 to 33,5, muriatic acid will consist of 1 hydrogen + 33,5 chlorine, and its representative number will be 34,5.

H.	C.		Muriatic Acid.
1	33,5	=	34,5

Muriatic acid may also be readily procured by acting upon common salt by sulphuric acid, the evolved gas must be received over mercury. It was first obtained pure by Dr Priestley, but its composition was discovered by Scheele, and has since been most ably investigated by Davy. Muriatic acid gas extinguishes flame; it is sour and acrid. Its specific gravity, compared with hydrogen, is = 17,25 to 1. 100 cubic inches = 39,5 grains. It is greedily absorbed by water, which takes up 480 times its bulk, and has its specific gravity increased from 1 to 1,210. Thus dissolved in water, it forms the liquid muriatic acid or spirit of salt, and may easily be procured by distilling a mixture of dilute sulphuric acid and common salt.

Hydrogen and Iodine exert a slow action under ordinary circumstances; but when iodine is presented to nascent hydrogen, they readily unite, and produce a gaseous acid, the *hydriodic acid.* It is prepared by the action of moist iodine upon phosphorus, and must be received over mercury. It is colourless, very sour, and smells like muriatic acid. Its specific gravity to hydrogen is as 60,7 to 1. It is instantly decomposed by chlorine, which produces muriatic acid, and the blue vapour of iodine is rendered evident.

It consists of - - 1 hydrogen,
117 iodine,

Hydriodic acid = 118

2. *Nitrogen.* (i. e. produce of nitric acid.)

This was first recognised as a distinct aëriform fluid by Dr Rutherford in 1772. (Thesis, *De aere Mephitico.*) It may be obtained by heating phosphorus in a confined portion of dry atmospheric air, which is a mixture of nitrogen and oxygen; the phosphorus absorbs the latter, and the former gas remains. After repeated washing with lime-water, it may be considered as pure.

100 cubic inches weigh 29,25 grains; so that its specific gravity, compared with hydrogen, is as 13 to 1. It is tasteless, inodorous, and insoluble in water. It does not support combustion, and is fatal to animals; hence was called azote. It is not inflammable; but when its compounds are submitted to Voltaic decomposition, it is attracted by the negative pole.

Nitrogen and Oxygen.—These bodies unite in four proportions, and form the compounds called,

1. Nitrous oxide.
2. Nitric oxide.
3. Nitrous acid.
4. Nitric acid.

Nitrous oxide may be obtained by distilling nitrate of ammonia at a temperature of about 420°. The gas which passes off may be collected over water, and is *nitrous oxide.* 100 cubic inches weigh 46,125 grains; its specific gravity, therefore, to hydrogen is as 20,5 to 1. The taste of this gas is sweet, and its smell peculiar, but agreeable. Its singular effects resembling intoxication when respired, were first ascertained by Sir H. Davy. It supports combus-

tion. It is easily absorbed by water, which takes up about its own bulk.

The best analysis of this gas is effected by detonation with hydrogen; one volume of nitrous oxide requires one volume of hydrogen. This mixture, fired by the electric spark, produces water, and one volume of nitrogen remains. Now, as one volume of hydrogen takes one-half volume of oxygen to form water, nitrous oxide must consist of two volumes of nitrogen and one volume of oxygen; these three volumes being so condensed in consequence of chemical union, as only to fill the space of two volumes. The specific gravity of nitrogen, compared with oxygen, is as 13 to 15; nitrous oxide, therefore, consists of - - - 13 Nitrogen.
7,5 Oxygen.

Number for nitrous oxide, 20,5

or,

Nitrogen.	Oxygen.		Nitrous oxide.
13	7,5	=	20,5

Nitric Oxide is usually obtained by presenting certain substances to nitric acid, which abstract a portion of its oxygen, leaving the remaining element in such proportion as to constitute the gas in question; for this purpose, some copper filings may be put into a gas bottle with nitric acid diluted with thrice its bulk of water; an action ensues, red fumes are produced, and there is a copious evolution of the gas, which may be collected and preserved over water. This gas is presently recognised by the red fumes which it produces when brought into the contact of air.

It extinguishes most burning bodies, but phosphorus readily burns in it. Its specific gravity to hydrogen is as 14 to 1. 100 cubic inches weigh = 31,5 grains.

It does not detonate when mixed with oxygen, and subjected to the electric spark; but it may be decomposed by the action of some of the metals at high temperatures, which absorb its oxygen. One volume of nitric oxide is thus resolved into equal volumes of oxygen and nitrogen. If, therefore, we call nitrous oxide a compound of 1 proportion of nitrogen + 1 oxygen, then nitric oxide may be considered as consisting of 1 nitrogen + 2 oxygen, or by weight, 13 nitrogen + 15 oxygen, and its symbol will stand thus:

Nitrogen.	Oxygen.		Nitric oxide.
13	7,5	=	28.
	7,5		

Nitrous Acid Gas.—When nitric oxide is presented to oxygen, the two gases combine, and a new gaseous compound of a deep orange colour results. This compound is not easily examined, because it is absorbed both by quicksilver and water, so that we are obliged to resort to exhausted glass vessels for its production. When we thus mix two volumes of nitric oxide with one volume of oxygen, the gases become condensed to about half their original volumes, and form nitrous acid gas. This gas supports the combustion of the taper, of phosphorus, and of charcoal, but extinguishes sulphur. It is readily absorbed by water, forming a green sour liquid. Its specific gravity to hydrogen is as 28,6 to 1, and 100 cubic inches = 64,48 grains.

It is obvious that this nitrous acid gas must consist of 13 nitrogen + 30 oxygen, and, therefore, its number is 43, for nitric oxide is composed of equal volumes of nitrogen and oxygen, and one additional volume of oxygen, or two proportions by weight are added to form nitrous acid.

Nitrogen.	Oxygen.	
13	7,5	
	7,5	
	7,5	30
	7,5	

Nitric Acid.—The fourth compound of nitrogen with oxygen is the nitric acid; the nature of which was first demonstrated by Mr Cavendish in 1785. (*Phil. Trans.*) It is usually obtained from nitre, three parts of which are distilled with two of sulphuric acid.

The nitric acid is a colourless liquid, extremely sour and corrosive. Its specific gravity is 1,42; it always contains water, which modifies its specific gravity. At 250° it boils and distils over without change. At 40° it congeals. It absorbs water from the air, and its bulk is thus increased, while its specific gravity is diminished. It is usually coloured by nitrous acid gas.

Nitric acid in its dry state, that is, as it exists combined with metallic oxides, may be regarded as composed of one proportion of nitrogen = 13, and 5 of oxygen = 37,5, and this will be the symbol representing its composition.

Nitrogen.	Oxygen.	
13	7,5	
	7,5	
	7,5	37,5
	7,5	
	7,5	

Consequently, the representative number of *dry* nitric acid is 50,5. But in its liquid state it always contains water, and when, in this state, its specific gravity is 1,5, it may be regarded as a compound of one proportion of dry acid and two of water, and this may be numerically expressed thus:

Acid. Water.
50,5 + 17 = 67,5 liquid acid.
spe. grav. 1,5.

Nitromuriatic Acid.—This term has been applied to the *Aqua Regia* of the alchemists. When nitric and muriatic acids are mixed, they become yellow, and acquire the power of readily dissolving gold, which neither of the acids possessed separately. This mixture evolves chlorine, a partial decomposition of both acids having taken place, and water, chlorine, and nitrous acid

gas, are thus produced; that is, the hydrogen of the muriatic acid abstracts oxygen from the nitric to form water. The result must be chlorine and nitrous acid. (Davy, *Journal of Sciences and the Arts*, Vol. I. p. 67.)

Nitrogen and Chlorine.—These gases do not unite *directly*, but the compound may be obtained by exposing a solution of nitrate or muriate of ammonia to the action of chlorine, at a temperature of 60° or 70°. The gas is absorbed, and an oil-like fluid, heavier than water, is produced. It was discovered by M. Dulong. (*Annales de Chimie*, Vol. LXXXV.) Its specific gravity is 1,6; it is not congealed by cold. This substance is dangerously explosive, and is decomposed with violent detonation by many combustibles, especially phosphorus, and fixed oils. Alcohol quietly changes it into a white substance. Mercury absorbs the chlorine, and evolves nitrogen. It yields, by decomposition, 1 volume of nitrogen and 4 of chlorine; and as the specific gravity of nitrogen to chlorine is as 13 to 33,5, so it may be said to consist of 1 proportion of nitrogen + 4 proportions of chlorine, or $\overset{N.}{13} + \overset{C.}{134}$ by weight, and its number will be 147.

Nitrogen.	Chlorine.	
13	33,5	
	33,5	134
	33,5	
	33,5	

Nitrogen and Iodine.—A compound of these bodies may be procured by pouring a solution of ammonia upon a very small quantity of iodine. Hydriodic acid is one product, and the other a brown powder, which detonates upon the slightest touch, and is resolved into nitrogen and iodine.

Nitrogen and Hydrogen—Ammonia or Volatile Alcali.—This gaseous compound may be obtained by heating a mixture of quicklime and muriate of ammonia. It must be collected over mercury. It is a permanently elastic gas at common temperatures, extremely pungent and acrid, but when diluted by mixture with common air, agreeably stimulant. It converts most vegetable blues to green, and the yellows to red, properties which belong to the bodies called alcalies. Ammonia, therefore, has been termed volatile alcali.

Its specific gravity to hydrogen is as 8 to 1—100 cubical inches weighing 18 grains. It extinguishes flame, but forms an inflammable mixture with common air and with oxygen.

Water at the temperature of 50° takes up 670 times its volume of ammonia; its bulk is increased, and specific gravity diminished; that of a saturated solution is 0,875, water being 1,000. Ammonia may be decomposed by detonation with oxygen; also by passing it through a red hot iron tube. It yields one volume of nitrogen and three of hydrogen, and therefore consists by weight of 13 nitrogen 3 + hydrogen, and its representative number is 16.

Ammonia and Chlorine.—When these gases are mixed, a partial decomposition of the former ensues. On mixing 15 parts of chlorine and 40 of ammonia, heat and light are evolved; 5 parts of nitrogen are liberated, and muriate of ammonia is formed.

Ammonia and Muriatic Acid—Muriate of Ammonia—Sal Ammoniac.—This salt may be produced directly by mixing equal volumes of ammonia and muriatic acid, when an entire condensation ensues.

The specific gravity of ammonia to muriatic acid is as 16. to 34,5, therefore, muriate of ammonia consists of 34,5 muriatic acid + 16 ammonia.

Ammo.	Mur. Acid.
16	34,5

Ammonia and Nitric Acid—Nitrate of Ammonia.—This salt may be procured by the direct union of ammonia with nitric acid—or more easily by saturating dilute nitric acid with carbonate of ammonia. It has been mentioned as the source of nitrous oxide, and when heated is entirely resolved into that gas and water. It consists of one proportion of nitric acid = 50,5 + one proportion of ammonia = 16, and therefore the representative number of the nitrate of ammonia is 66,5. Or it may be considered as containing 2 proportions of nitrogen, 3 of hydrogen, and 5 of oxygen, as the following symbols show:

Nitric Acid.

Nitrogen.	Oxygen.	
13	7,5	
	7,5	
	7,5	37,5 + 50,5
	7,5	
	7,5	

Acid.		Ammo.		Nitrat. of Ammo.
50,5	+	16	=	66,5.

Ammonia.

Nitrogen.	Hydrog.	
13	1	
	1	3 = 16.
	1	

Nitrous oxide consists of 1 proportion of nitrogen = 13 + 1 of oxygen = 7,5; hence the two proportions of nitrogen in the salt (1 in the acid and 1 in the ammonia) will require two of oxygen to produce nitrous oxide, and the remaining 3 of oxygen will

unite to the 3 of hydrogen, and form water. And accordingly nitrous oxide and water are the only possible results; so that the elements, after the decomposition of the salt, are arranged thus:

Nitrogen. 13	Oxygen. 7,5	= Nitrous oxide.
Nitrogen. 13	Oxygen. 7,5	

Hydrog. 1	Oxygen. 7,5	= Water.
Hydrog. 1	Oxygen. 7,5	
Hydrog. 1	Oxygen. 7,5	

Atmospheric Air may be considered as a mixture of 21 *per cent.* of oxygen with 79 of nitrogen; 100 cubical inches at mean pressure and temperature weigh 30,195 grains, and its specific gravity compared with hydrogen is as 13,42 to 1.

3. *Sulphur.*

A substance of a pale yellow colour, insipid and inodorous, but exhaling a peculiar smell when heated. Its specific gravity is 1,990. It is principally a mineral product, and occurs crystallized, its primitive form being a very acute octoëdron, with an oblique base. When sulphur is heated to about 1[illegible]0° it volatilizes, and its peculiar odour is strong and disagreeable; at 225° it liquefies; between 350° and 400° it becomes viscid, and of a deep brown colour; and at about 600° it quickly sublimes. When slowly cooled after fusion, it forms a fibrous crystalline mass.

Sulphur forms compounds with oxygen, chlorine, iodine, and hydrogen.

Sulphur and Oxygen.—To oxygen it unites in two proportions, giving rise to the compounds, sulphurous and sulphuric acid. *Sulphurous acid*, or, as it should rather be called, *sulphurous oxide*, is a gaseous body, which may be obtained by several processes. It may be procured directly by burning sulphur in oxygen gas, or indirectly by heating mercury in sulphuric acid. It must be collected and preserved over mercury, for water takes up rather more than 30 times its bulk of this gas, forming the liquid sulphurous acid, which, when recently prepared, has a sulphureous astringent taste, and destroys many vegetable colours; but by keeping it acquires a sour flavour, and reddens the generality of vegetable blues. If sulphur be burned in oxygen, sulphurous acid is produced, without any change in the volume of the gas, so that its composition is easily learned by the increase of weight; and as 100 cubic inches of oxygen (weighing 33,75 grains) dissolve 33,75 grains of sulphur, it is obvious that the sulphurous acid is composed of equal weights of sulphur and oxygen; and if we regard it as consisting of two proportions of oxygen and one of sulphur, the latter element will be represented by the number 15; and the sulphurous acid, consisting of 1 proportion of sulphur = 15, and 2 proportions of oxygen = 15, will be represented by 30, which is also its relative specific gravity to hydrogen, considering the latter as = 1; 100 cubical inches of sulphurous acid gas weigh 67,5 grains. This gas has a suffocating nauseous odour, an astringent taste; it extinguishes flame, and kills animals. When mixed in equal volume with ammonia, a yellowish salt is produced, which is a sulphite of ammonia, and which consists of 60 sulphurous acid + 16 ammonia.

Sulphuric Acid.—This body was formerly obtained by the distillation of green vitriol, and called *oil of vitriol.* It is now procured in this country by burning a mixture of 8 parts of sulphur and 1 of nitre in close chambers containing water, by which the fumes produced are absorbed, and by evaporation the acid is procured in a more concentrated state.

Sulphuric acid, as usually met with, is a limpid colourless fluid, having a specific gravity of 1,85,—it boils at 620°, and freezes at 15°. It is very acrid and caustic, and when diluted with water, produces a very sour liquid. It rapidly absorbs water from the atmosphere, and upon sudden mixture with water produces much heat.

In sulphuric acid 1 proportion of sulphur = 15, is combined with 3 proportions of oxygen = 22,5, and, consequently, *dry* sulphuric acid is correctly represented by 15 + 22,5 = 37,5, but it only exists in this state (like the nitric and chloric acids) when united with bases, and in its ordinary state contains water, and should, therefore, be called *Hydrosulphuric Acid.* It has been found by experiment, that 100 parts of sulphuric acid, specific gravity 1,9, contain 18,2 of water, consequently, it may be looked upon as composed of 1 sulphur + 3 oxygen + 1 water:

or of 15 sulphur
22,5 oxygen
8,5 water

46 = number for liquid sulphuric acid.

The *formation* of sulphuric acid by the combustion of sulphur and nitre is as follows:

The sulphur, by burning in contact with atmospheric air, forms *sulphurous acid.* The nitre gives rise to the production of *nitric oxide*, which, with the oxygen of the air, *produces nitrous acid gas.* When these gases (*i. e.* sulphurous and nitrous acids) are *perfectly dry*, they do not act upon each other, but moisture being present in small quantity, they form a white solid, which is instantly decom-

posed when put into water; the nitrous acid reverts to the state of nitric oxide, having transferred one additional proportion of oxygen to the sulphurous acid, and, with water, producing the sulphuric acid; while the nitric oxide, by the action of the air, again affords nitrous acid, which plays the same part as before.

Sulphurous acid consists of

Sulphur.	Oxygen.	
15	7,5	15 ; and nitrous acid contains
	7,5	

Nitrogen	Oxygen.	
13	7,5	
	7,5	
	7,5	30 ; hence every *two* portions of sulphurous acid require *one* of nitrous acid, which transfers *two* of oxygen, and passes back into the state of nitrous gas, sulphuric acid
	7,5	

being, at the same time, produced. The sulphurous acid and nitrous acid, therefore, before decomposition, may be thus represented:

	Oxygen.		
Sulphur. 15	7,5		
	7,5	15	
Sulphur. 15	7,5		Sulphurous acid.
	7,5	15	

Nitrogen	Oxygen.		
13	7,5		
	7,5		
	7,5	30	Nitrous acid gas.
	7,5		

And after decomposition as follows:

Sulphur. 15	Oxygen. 7,5		
	7,5	22,5	
	7,5		
Sulphur. 15	Oxygen. 7,5		Sulphuric acid.
	7,5	22,5	
	7,5		

Nitrogen.	Oxygen.		
13	7,5	15	Nitric oxide.
	7,5		

The decomposition of sulphuric acid may be effected by passing it through a red hot platinum tube, when it is resolved into sulphurous acid. oxygen, and water. Its uses are numerous and important.

Sulphuric Acid and Ammonia—Sulphate of Ammonia—may be obtained by passing ammonia into sulphuric acid, but is usually prepared by saturating dilute sulphuric acid with carbonate of ammonia. By crystallization it affords six sided prisms. This salt is important as a source of the muriate of ammonia. It dissolves in twice its weight of water at 60°, and consists of 1 proportion of sulphuric acid $= 37,5 +$ 1 proportion of ammonia $= 16$. Its number, therefore, is 53,5. When heated, ammonia is given off, and a *supersulphate* remains, consisting of 2 proportions of acid + 1 of alcali.

Sulphur and Chlorine—Chloride of Sulphur.—When sulphur is heated in chlorine, it absorbs rather more than twice its weight of that gas. 10 grains of sulphur absorb 30 cubic inches of chlorine, and produce a greenish-yellow liquid, consisting of 15 sulphur + 33,5 chlorine, and represented, therefore, by the number 48,5. It exhales suffocating and irritating fumes when exposed to the air. Its specific gravity $= 1,6$. It does not affect dry vegetable blues; but when water is present, instantly reddens them. Sulphur is deposited, and sulphureous, sulphuric, and muriatic acids are formed in consequence of a decomposition of the water.

Sulphur and iodine readily unite, and form a black crystallizable compound.

Sulphur and Hydrogen—Sulphuretted Hydrogen Gas.—This gaseous compound of sulphur and hydrogen was discovered by Scheele in 1777. It may be obtained by presenting sulphur to nascent hydrogen, which is the case when sulphuret of iron is acted upon by dilute sulphuric acid. This gas may be collected over water, though, by agitation, that fluid absorbs thrice its bulk. It has a fetid odour. Its specific gravity to hydrogen is as 16 to 1. 100 cubic inches $= 36$ grains. It extinguishes flame; and, when respired, proves fatal. It is very deleterious, even though largely diluted with atmospheric air. When one volume of sulphuretted hydrogen, and $1\frac{1}{2}$ of oxygen, are inflamed in a detonating tube, 1 volume of sulphurous acid is produced, and water is formed. Thus the sulphur is transferred to one volume of the oxygen, and the hydrogen to the half volume. Sulphuretted hydrogen, therefore, consists of 15 sulphur + 1 hydrogen, and its number is 16.

Chlorine and iodine instantly decompose sulphuretted hydrogen; sulphur is deposited, and hydrochloric and hydriodic acids are formed.

Sulphuretted hydrogen and ammonia readily unite in equal volumes, and produce *hydrosulphuret of ammonia.* At first white fumes appear, which become yellow. A yellow crystallized compound results, consisting of 16 sulphuretted hydrogen, 8 ammonia.

It is of much use as a test for the metals, and may be procured by distilling, at nearly a red heat, a mixture of 6 parts of slacked lime, 2 of muriate of ammonia, and 1 of sulphur.

There is another compound of hydrogen and sulphur, which has been called supersulphuretted hydrogen. It is a liquid, formed by adding muriatic acid to a solution of sulphuret of potash, and appears to consist of two proportions of sulphur = 30 + one of hydrogen = 1.

Sulphur and nitrogen do not combine. Sulphur always, in its ordinary state, contains hydrogen, which it gives off during the action of various bodies, for which it has a powerful attraction.

4. *Phosphorus*

Is obtained by distilling phosphoric acid with charcoal at a red heat. When pure, it is nearly colourless, semitransparent, and flexible. Its specific gravity = 1,770. It melts, when air is excluded, at 105°. If suddenly cooled after having been heated to 140°, it becomes black; but if slowly cooled, remains colourless. At 500°, it boils, and rapidly evaporates. When exposed to air, it exhales luminous fumes, having a peculiar alliaceous odour; it is tasteless. At a temperature of about 100°, it takes fire, and burns with intense brilliancy, throwing off copious white fumes. If, instead of burning phosphorus with free access of air, it be heated in a confined portion of very rare air, it enters into less perfect combustion, and three compounds of phosphorus with oxygen are the result, each characterized by distinct properties. The first is a red solid, less fusible than phosphorus; the second is a white substance, more volatile than phosphorus; the third a white and fixed body.

The red solid consists of a mixture of phosphorus and oxide of phosphorus. *Oxide of phosphorus* is the white substance with which phosphorus becomes encrusted when kept for some time in water. It is very inflammable, and less fusible and volatile than phosphorus.

Phosphorous acid is best procured by mixing chloride of phosphorus with water, filtering and evaporating the solution, when a white crystallized solid is obtained, which is a compound of the phosphorous acid with water. (See *Chloride of Phosphorus.*)

The *phosphoric acid* may be produced by burning phosphorus in excess of oxygen. There is intense heat and light produced, and white deliquescent flocculi line the interior of the receiver. Phosphoric acid may also be obtained by acting upon phosphorus by nitric acid.

The composition of phosphoric acid is learned by ascertaining the bulk of oxygen absorbed during the perfect combustion of a given weight of phosphorus, which is = 4,4 cubic inches for each grain; so that 100 grains of phosphorus would require, for conversion into phosphoric acid, 440 cubic inches of oxygen = 148,5 grains. Hence phosphoric acid, considered as a compound of one proportion of phosphorus, and two proportions of oxygen, will consist of 10 phosphorus + 15 oxygen.

Phosphoric acid is a deliquescent substance; when fused it has been called Glacial Phosphoric Acid. It is inodorous, very sour, fixed in the fire, and unchanged by heat. As commonly prepared, it is an unctuous fluid. Specific gravity = 2.

Phosphite of Ammonia may be obtained in delicate annular crystals, decomposable by heat.

Phosphate of Ammonia is a common ingredient in the urine of carnivorous animals. It may be obtained pure by saturating phosphoric acid with ammonia, and forms crystals in four-sided prisms.

Phosphorus and Chlorine.—These elements unite in two proportions, forming two definite compounds,—the chloride and bichloride of phosphorus. When phosphorus is submitted to the action of chlorine, it burns with a pale yellow flame, and produces a white volatile compound, which attaches itself to the interior of the vessel. This substance was long mistaken for phosphoric acid, but its volatility is alone sufficient distinction; it rises in vapour at 200°. It is fusible and crystallizable; and when brought into the contact of water, a mutual decomposition is effected, and phosphoric and muriatic acids result. When passed through a red-hot porcelain tube with oxygen, phosphoric acid is produced, and chlorine evolved.

With ammonia it forms a singular compound, which, though consisting of three volatile bodies, remains unchanged at a white heat,—it is insoluble in water.

When phosphorus is burned in chlorine, one grain absorbs nine cubic inches; so that the compound formed must be regarded as the *bichloride*, and consists of 10 of phosphorus + 67 of chlorine, and its number is 77.

The *Chloride of Phosphorus*, consisting of 10 phosphorus + 33,5 chlorine, is procured by distilling a mixture of phosphorus and corrosive sublimate, which is a bichloride of mercury. In this experiment calomel, or chloride of mercury, is formed, and the phosphorus combines with one proportion of chlorine.

The chloride of phosphorus, when first obtained, is a liquid of a reddish colour; it soon deposites a portion of phosphorus, however, and becomes limpid and colourless. Its specific gravity = 1,45. Exposed to the air it exhales acid fumes: it does not change the colour of dry vegetable blues. Chlorine converts it into bichloride. Ammonia separates phosphorus, and produces the singular triple compound before adverted to.

Chloride of phosphorus acts upon water with great energy, and produces muriatic and phosphorous acids, while the bichloride produces muriatic and phosphoric acids: for as in the bichloride there are two proportions of chlorine, so, in acting upon water, two of oxygen must be evolved, which, uniting to one of phosphorus, generate phosphoric acid. The chloride of phosphorus, on the contrary, containing only one proportion of chlorine, produces muriatic acid and phosphorous acid, when it decomposes water.

Before decomposition.

	Chlorid. of Phosp.		Water.
1 Chlorine = 33,5	43,5	1 Hydrog. = 1	8,5
1 Phospho. = 10		1 Oxygen = 7,5	

After decomposition.

		Muriatic Acid.		Phosp. Acid.
1 Chlorine = 33,5	}	36,5	1 Phospo. = 10	} 17,5
1 Hydrog. = 1			1 Oxygen = 7,5	

But the phosphorous acid thus produced always contains water, which it throws off when heated in ammonia, forming, with that alcali, a dry phosphite. This experiment shows that the *Hydrophosphorous acid* consists of 2 proportions of phosphorous acid = 35 + 1 water = 8,5.

Phosphorus and Iodine.—When these substances are brought together in an exhausted vessel, they act violently, and form a reddish compound; it decomposes water with great energy, and produces phosphorous and hydroiodic acids.

Phosphorus and Hydrogen.—When phosphorus is presented to nascent hydrogen, two gaseous compounds result. The one inflames spontaneously upon the contact of the atmosphere. This may be procured by heating phosphorus in a solution of caustic potash, or better, by acting upon phosphuret of lime by dilute muriatic acid. The gas may be collected over water. It is colourless, has a nauseous odour like onions, a very bitter taste, and inflames when mixed with air, a property which it loses by being kept over water. For our knowledge of the properties and composition of this gas we are chiefly indebted to Dr Thomson, who has shown that the hydrogen suffers no change of bulk in uniting to the phosphorus; so that the difference of weight between this gas and pure hydrogen indicates the weight of phosphorus: 100 cubic inches of phosphuretted hydrogen = 24,75 grains; hence the gas may be regarded as containing one proportion of phosphorus and one of hydrogen, or 10 + 1 = 11.

The next compound of phosphorus and hydrogen has been called, by Sir H. Davy, *hydrophosphoric gas*. It is procured by heating the solid hydrophosphorous acid. The gas must be collected over mercury. Its specific gravity to hydrogen is as 12 to 1. It is not spontaneously inflammable, but explodes when heated with oxygen. It inflames spontaneously in chlorine. It smell is less disagreeable than the former. It consists of 2 of hydrogen and 1 of phosphorus $\overset{H.}{2} + \overset{P.}{10} = 12$; but the two volumes of hydrogen are condensed into one. 100 cubic inches weigh 27 grains.

When hydrophosphorous acid is decomposed for the production of this gas, phosphoric acid is always generated. Hydrophosphorous acid has been stated to contain two proportions of phosphorous acid + one of water. Hence the elements

$$\left.\begin{array}{l}\text{20 phosphorus}\\ \text{15 oxygen}\end{array}\right\} = \text{phosphorous acid,}$$
$$\left.\begin{array}{l}\text{7,5 do.}\\ \text{1— hydrogen}\end{array}\right\} = \text{water,}$$

or 43,5 parts of hydrophosphorous acid contain

20 phosphorus
22,5 oxygen
1 hydrogen.

The three proportions of oxygen = 22,5 will require one proportion and a half of phosphorus = 15 to form phosphoric acid, and the remaining half proportion of phosphorus will unite to the one of hydrogen to form hydrophosphoric gas, which consist of 5 phosphorus + 1 hydrogen.

To avoid fractions the phenomena may be stated thus:

Four proportions of hydrophosphoric acid contain

4 phosphorus		=	40.
4 oxygen		=	30.
2 do.	} in the	=	15.
2 hydrogen	} water	=	2.

The whole of the oxygen, amounting to 6 proportions (*i. e.* 7,5 × 6 = 45), unites to three proportions of phosphorus (10 × 3 = 30) to form phosphoric acid. The two of hydrogen = 2, combine with the remaining proportion of phosphorus = 10 to form hydrophosphoric gas.

Phosphorus and Nitrogen produce no definite compound.

Phosphorus and Sulphur may be readily united by fusion in an exhausted vessel. When one proportion of phosphorus is united to one of sulphur (10 + 15), the compound bears a high temperature without decomposition.

5. *Carbon.*

The purest form of this element is the diamond, a colourless transparent body found in certain alluvial strata; its primitive crystalline form is the regular octoëdron. Its specific gravity = 3,50.

Another form of carbon is charcoal, and of this the purest variety is lamp-black. Charcoal is possessed of some very curious properties in regard to absorbing gases, and removing the colour, smell, and taste of certain vegetable and animal bodies.

Carbon and Oxygen.—There are two compounds of carbon and oxygen,—the carbonic oxide and the carbonic acid.

Carbonic Oxide is usually obtained by subjecting carbonic acid to the action of substances which abstract a portion of its oxygen. Upon this principle, carbonic oxide gas is produced by heating chalk and charcoal, or chalk and iron or zinc filings. The gas should be well washed, and may be preserved over water. Its specific gravity to hydrogen is as 13,2 to 1; 100 cubical inches weighing 29,7 grains. It is fatal to animals, extinguishes flame, and burns with a pale blue lambent light when mixed with, or exposed to, atmospheric air. When a stream of carbonic oxide is burnt under a dry bell glass of air or oxygen, no moisture whatever is deposited. When *two* volumes of carbonic oxide and *one* of oxygen are acted on by the electric spark, a detonation ensues, and *two* volumes of carbonic acid are produced. Whence it appears, that carbonic acid contains just twice as much oxygen as carbonic oxide. Carbonic oxide may be considered as a compound of one volume of oxygen and one volume of gaseous carbon, or of one proportion of carbon and one of oxygen, the latter being so expanded as to occupy two volumes.

The representative number of charcoal, as obtained by considering this gas as a compound of one proportion of charcoal and one of oxygen, is 5,7 and 5,7 carbon + 7,5 oxygen = 13,2 carbonic oxide.

Carbonic acid may be obtained by burning carbon, either pure charcoal or the diamond, in oxygen gas; the oxygen suffers no change of bulk, so that the composition of carbonic acid is easily learned by comparing its weight with that of an equal volume of pure oxygen; 100 cubic inches of oxygen weigh 33,75 grains; 100 cubic inches of carbonic acid weigh 46,57 grains; hence 100 cubical inches of carbonic acid must consist of 33,75 grains of oxygen, + 12,82 grains of carbon, and 12,82 : 33,75 :: 5,7 : 15. Hence one proportion of charcoal = 5,7 + 2 proportions of oxygen, = 15, will constitute carbonic acid, represented by the number 20,7.

Carbonic acid is a most abundant natural product; the best mode of procuring it for experiment consists in acting upon pounded marble (carbonate of lime) by dilute muriatic acid. It may be collected over water, but must be preserved in vessels with glass stoppers, since water, at common temperature and pressure, takes up its own volume: under a pressure of two atmospheres it dissolves twice its volume, and so on. It becomes brisk and tart; by freezing, boiling, or exposure to the vacuum of the air-pump, the gas is given off again.

Carbonic Acid and Ammonia—Carbonate of Ammonia.—These gases readily combine, and produce one of the most useful and best known of the ammoniacal compounds.

When one volume of carbonic acid and two volumes of ammonia are mixed in a glass vessel, over mercury, a complete condensation ensues, and a subcarbonate of ammonia is produced.

It consists of 16 ammonia + 20,7 carbonic acid, and is represented by 36,7.

Carbonic Acid. 20,7	Ammonia. 16.	= 36,7.

If water be present, it so far overcomes the elasticity of the gas, as to enable the salt formed to take up another volume of carbonic acid, and thus a bicarbonate is formed.

Subcarbonate of ammonia crystallizes in octoëdrons, though it is generally met with in cakes broken out of the subliming vessel, being obtained by sublimation from a mixture of muriate of ammonia and chalk. Its odour is pungent; its taste hot and saline. A pint of water at 60° dissolves rather less than 4 ounces; by exposure to air it loses ammonia, and becomes a bicarbonate.

Chlorine and carbon do not combine; but *chlorine* unites with *carbonic oxide*, and produces a triple compound, called by Dr Davy *phosgene gas*, as it is most easily produced by exposing a mixture of equal volumes of chlorine and carbonic oxide to the action of light. A condensation = 0,5 takes place. The compound has a peculiar pungent odour. It is soluble in water, and is resolved into carbonic and muriatic acid gases. The weight of phosgene to hydrogen is as 46,7 to 1. 100 cubical inches weigh 107,075 grains. It condenses four times its volume of ammoniacal gas, producing a peculiar compound of a white colour.

Carbon and Hydrogen.—These bodies combine in two proportions, and form gaseous compounds, consisting of 1 carbon + 1 hydrogen, and 1 carbon + 2 hydrogen.

There are several processes by which they may be obtained. The first compound is obtained by the decomposition of alcohol by sulphuric acid. It may be collected over water; its specific gravity to hydrogen is 13,4. 100 cubic inches weigh 30,15 grains.

This gas is inflammable, burning with a bright yellowish white flame. One part by volume requires for perfect combustion three of oxygen, and two of carbonic acid result. When sulphur is heated in one volume of this gas, charcoal separates, and two volumes of sulphuretted hydrogen result. As hydrogen suffers no change of volume by combining with sulphur, it follows that carburetted hydrogen contains two volumes of hydrogen condensed into one, hence the quantity of oxygen required for its consumption.

Before detonation.

C. Hyd. 5,7 + 1	Oxygen. 7,5
	7,5
	7,5

After detonation.

Hydrogen. 1	Oxygen. 7,5	Water.

Carbon. 5,7	Oxygen. 7,5	Carbonic acid.
	7,5	

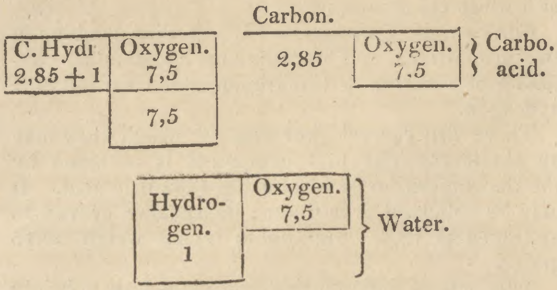
This gas, therefore, is constituted of 1 proportion of charcoal = 5,7 + 1 proportion of hydrogen = 1, and its number is 6,7.

When this gas is mixed with chlorine in the proportion of 1 to 2 by volume, the mixture on inflammation produces muriatic acid, and charcoal is abundantly deposited; but if the two gases be mixed in an exhausted vessel, or over water, they act slowly upon each other, and a peculiar fluid is formed, which appears like a heavy oil, hence this variety of carburetted hydrogen has been termed *olefiant gas*.

The other variety of carburetted hydrogen is often generated in stagnant ponds. It may be procured by passing the vapour of water over red-hot charcoal, and washing the gas thus afforded in lime-water, by which the carbonic acid is separated. 100 cubic inches of this gas weigh only 17,325 grains, so that its specific gravity to hydrogen is 7,7. It burns with a pale blue flame. It requires for perfect combustion twice its volume of oxygen; water is generated, and one volume of carbonic acid results, so that it contains only half the quantity of carbon existing in the former compound, or it may

be considered as composed of carbon 5,7 + 2 hydrogen.

Before detonation. After detonation.



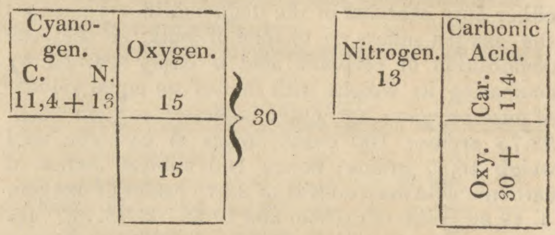
The hydrogen is in this, as in the former case, condensed to half its volume by union with carbon.

This variety of carburetted hydrogen is abundant in many coal mines, when it is often productive of terrible explosion, and known under the name of fire-damp.

There are many vegetable and animal substances, which, when submitted to destructive distillation, yield, among other products. a mixture of the two kinds of carburetted hydrogen. This is especially the case with pit-coal, the gas from which is importantly employed for the purposes of illumination.

Carbon and Nitrogen—Carburet of Nitrogen—Cyanogen.—This gaseous compound was discovered in 1815 by Gay-Lussac. It may be obtained by gently heating the Prussiate of mercury. The gas evolved must be collected over mercury. It has a penetrating and very peculiar smell; it burns with a purple flame. Its specific gravity to hydrogen is 24,4: 100 cubic inches weighing 54,9 grains. Water dissolves 4,5 volumes, and alcohol 23 volumes of this gas. It reddens vegetable blues. It may be analyzed by detonation with oxygen. One volume detonated with two of oxygen produces two volumes of carbonic acid, and one of nitrogen. Whence it appears that cyanogen consists of two proportions of carbon = 11,4, and one of nitrogen = 13, the nitrogen having suffered no change of bulk by uniting with the carbon,—or it may be said to consist of 2 volumes of gaseous carbon + 1 volume of nitrogen, the 3 being condensed into 1 volume.

Before detonation. After detonation.



Cyanogen combines with hydrogen, and produces a triple compound, the *Hydrocyanic* or *Prussic acid.* It may be obtained by moistening prussiate of mercury with muriatic acid, and distilling at a low temperature, having surrounded the receiver with ice. A liquid is thus obtained which has a strong pungent odour, very like that of bitter almonds; its taste is acrid, and it is highly poisonous. It volatilizes so rapidly as to freeze itself. It reddens litmus. The specific gravity of its vapour, compared with hydrogen, is 12,7, so that 100 cubic inches = 28,575 grains; detonated with oxygen it gives as results one volume of carbonic acid gas, half a volume of hydrogen, and half a volume of nitrogen, so that it consists of 1 volume of cyanogen + 1 volume of hydrogen.

Carbon and Sulphur—Sulphuret of Carbon.—This is a liquid obtained by passing sulphur over red-hot charcoal. When pure, it is transparent and colourless. It is very volatile, and has a pungent taste and peculiar fetid odour. It is inflammable, and, when burned with oxygen, produces sulphurous and carbonic acids. It consists of one proportion of charcoal and two of sulphur; 5,7 + 30 = 35,7.

6. *Boron*

Is obtained by the action of potassium on boracic acid, which appears to consist of 5,5 boron + 15 oxygen.

Tabular View of the Substances described in the First and Second Divisions of Part III., and of their Compounds, showing their Specific Gravities, Representation, Numbers, and Composition.

SUBSTANCES.	100 Cub. In. weigh	Specific Gravity compared to Hydrogen.	Air.	Water.	Number.	Composition.
Oxygen - -	33.75	15	1.117		7.5	
Chlorine - -	75.375	33.5	2.496		33.5	
Euchlorine - -	71.4375	31.75	2.365		63.5	30 oxy. + 33.5 chl.
Chloric acid -					71.	37.5 oxy. + 33.5 chl.
Iodine - -	264.9375	117.75	8.774	4.948	117.75	
Oxiodic acid - -					155.25	37.5 oxy. + 117.75. iodine.
Chloriodic acid - -						
Hydrogen - -	2.25	1	.0745		1	
Water - -				1	8.5	7.5 oxy. + 1 hy.
Muriatic acid gas -	38.8125	17.25	1.285		34.5	33.5 chl. + 1 hy.
——— solution -				1.21		480 vol. of gas.
Hydriodic acid -	133.5937	59.375	4.424		118.75	117.75 iode + 1 hy.
Nitrogen - -	29.25	13	.9687		13.	

SUBSTANCES.	100 Cub. In. weigh	Specific Gravity compared to			Number.	Composition.
		Hydrogen.	Air.	Water.		
Nitrous oxide	46.125	20.5	1.527		20.5	13 nit. + 7.5 oxy.
Nitric oxide	31.5	14	1.0432		28	13 nit. + 15 oxy.
Nitrous acid	64.485	28.66	2.1356		43	13 nit. + 30 oxy.
Nitric acid					50.5	13 nit. + 37.5 oxy.
Hydro-nitric acid				1.5	67.5	50.5 nit. ac. + 17 w.
Common air	30.195	13.42	1			21 oxy. + 79 n.
Chloride of nitrogen				1.6	147	13 n. + 134 chlo.
Iode of nitrogen						
Ammonia	18.	8	.5961		16	13 n. + 3 hy.
——— solution				.875		670 volumes.
Chlorate of ammonia						
Oxiodate of ammonia						
Chloriodate of ammonia						
Muriate of ammonia				1.45	50.5	16 am. + 34.5 m. a.
Hydriodate of ammonia					134.75	16 am. + 118.75 hy.
Nitrite of ammonia						
Nitrate of ammonia				1.5785	66.5	16 am. + 50.5 n. a.
Sulphur				1.99	15	
Sulphurous acid	67.5	30	2.2354		30	15 sul. + 15 oxy.
Hydro-sulphuro-nitric oxide						
Sulphite of ammonia					76.	16 am. + 60 sul. acid.
Sulphuric acid					37.5	15 sul. + 22.5 oxy.
Hydro-sulphuric acid				1.9	46	37.5 s. a. + 85 water.
Glacial sulphuric acid						
Sulphate of ammonia					53.5	37.5 s. a. + 16 am.
Sulphurane, or chloride of sulphur				1.6	48.5	15 sul. + 33.5 chl.
Iode of sulphur						
Sulphuretted hydrogen	36	16	1.1922		16	15 sul. + 1 hy.
Hydroguretted sulphur						
Hydrosulphuret of ammonia					48	32 s. h. + 16 am.
Phosphorus				1.77	10	
Oxide of phosphorus					27.5	20 P. + 7.5 oxy.
Phosphorous acid					17.5	10 P. + 7.5 oxy.
Hydrophosphorous acid					43.5	35 P. a. + 8.5 water.
Phosphite of ammonia						
Phosphoric acid				2.85	25	10 P. + 15 oxy.
Phosphate of ammonia						
Chloride of phosphorus				1.45	43.5	10 P. + 33. 5 chl.
Bichloride of phosphorus					77	10 P. + 67 chl.
Ammoniaco-bichloride of phosphorus						
Iode of phosphorus						
Hydro-phosphoric gas	27	12	.8942		12	P. 10 + hy. 2.
Phosphuretted hydrogen	24.75	11	.8196		11	P. 10 + hy. 1.
Sulphuret of phosphorus					35	P. 20 + sul. 15.
Carbon (Diamond)				3.5	5.7	
Carbonic oxide	29.7	13.2	.9836		13.2	Carb. 5.7 + oxy. 7.5.
Phosgene gas	107.075	46.7	3.48		46.7	C. o. 13.2 + chl. 33.5.
Carbonic acid	46.575	20.7	1.5425		20.7	Carb. 5.7 + oxy. 15.
Carbonate of ammonia					36.7	C. a. 20.7 + am. 16.
Bicarbonate of ammonia					57.4	C. a. 41.4 + am. 16.
Carburetted hydrogen	17.325	7.7	.5738		7.7	Carb. 5.7 + hy. 2.
Bicarburetted hydrogen	30.15	13.4	.9985		6.7	Carb. 5.7 + hy. 1.
Olefiant ether				1.2201	46.9	Olef. 13.4 + chl. 33.5.
Cyanogen	54.9	24.4	1.818		24.4	Carb. 11.4 + n. 13.
Chloro-cyanic acid	65.1375	28.95	2.1572		57.9	Cy. 24.4 + ch. 33.5.
Hydro-cyanic acid	28.575	12.7		.7058	25.4	Carb. 11.4 + azol. 13 + hy. 1.
Hydro-cyanate of ammonia			.9463			
Sulphuret of carbon				1.272	35.7	Carb. 5.7 + sul. 30.
Phosphuret of carbon						
Boron					5.5	
Boracic acid				1.803	20.5	B. 5.5 + oxy. 15.
Hydro-boracic acid				1.479	37.5	B. a. 20.5 + w. 17.
Borate of ammonia (Hydro)					53.5	B. a. 20.5 + am. 16 + w. 17.

The third division of undecompounded bodies embraces the *Metals*. Their general properties, and those of their most important compounds, are, with few exceptions, amply detailed in the body of the work. On the present occasion, it will be required to notice those of more recent discovery, and point out the applications of the law of proportions to their various combinations.

Chemists have adopted different principles of subdivision in regard to the metals, sometimes founding them upon their mechanical, and sometimes upon their chemical qualities. In the former case, malleability, ductility, or tenacity. have been selected as leading characters; in the latter, fusibility and the action of heat and air have furnished characters for classification.

In the present state of our knowledge, it seems that the relative attractions of the metals for oxygen may be most usefully and scientifically assumed as the basis of arrangement, and they may be thus classified under five heads.

The first embraces those metals which neither absorb oxygen nor decompose water at any temperature; their oxides are reducible at a heat below redness.

1. Gold.
2. Silver.
3. Platinum.
4. Palladium.
5. Rhodium.
6. Iridium.

The second division contains metals which, when heated to a *certain* temperature, absorb and retain oxygen; at higher temperatures they again give it off.

1. Osmium.
2. Mercury.
3. Lead.
4. Nickel.

The metals of the third division absorb oxygen even when at a temperature above redness. They are incapable of decomposing water at any temperature.

$$\left.\begin{array}{l}\text{1. Arsenic.}\\ \text{2. Molybdenum.}\\ \text{3. Chrome.}\\ \text{4. Tungsten.}\\ \text{5. Columbium.}\end{array}\right\}\text{Acidifiable metals.}$$

6. Antimony.
7. Uranium.
8. Cerium.
9. Cobalt.
10. Titanium.
11. Bismuth.
12. Copper.
13. Tellurium.

The metals of the fourth division absorb oxygen even at high temperatures, and, when heated to redness, are capable of decomposing water.

1. Iron.
2. Tin.
3. Zinc.
4. Manganese.

The fifth class includes metals which absorb oxygen, and which rapidly decompose water, at all temperatures.

1. Potassium.
2. Sodium.
3. Barium.
4. Strontium.
5. Calcium.
6. Magnesium.

The sixth class includes bodies which, by analogy, are considered metallic, but of which the oxides have not hitherto been reduced.

1. Silicium.
2. Alumium.
3. Zirconium.
4. Ittrium.
5. Glucium.

It appears from this statement that the metals are thirty-eight in number.

If we arrange the metals according to their specific gravities, they stand as follows:

1. Platinum,	21.00
2. Gold,	19.30
3. Tungsten,	17.50
4. Mercury,	13.50
5. Palladium,	11.50
6. Lead,	11.35
7. Silver,	10.50
8. Bismuth,	9.80
9. Uranium,	9.00
10. Copper,	8.90
11. Arsenic,	8.35
12. Nickel,	8.25
13. Cobalt,	8.00
14. Iron,	7.78
15. Molybdenum,	7.40
16. Tin,	7.30
17. Zinc,	7.00
18. Manganese,	6.85
19. Antimony,	6.70
20. Tellurium,	6.10
21. Sodium,	0.972
22. Potassium,	0.865

It will be seen, therefore, that the metals include the heaviest and lightest solids. Of the remaining metals, the specific gravities have not been ascertained.

1. *Gold.*

Gold occurs in nature in a metallic state, alloyed with a little silver or copper; it may be obtained pure by dissolving it in nitro-muriatic acid, evaporating the solution to dryness, redissolving the dry mass in distilled water, filtering, and adding to it a solution of sulphate of iron; a black powder falls, which, after having been washed with dilute muriatic acid and distilled water, affords on fusion a button of pure gold.

Pure gold is of a deep yellow colour. It melts at a bright red heat, and, when in fusion, appears of a brilliant green colour. It shows no tendency to unite to oxygen when exposed to its action in a state of fusion; but if an electric discharge be passed through a very fine wire of gold, a purple powder is produced, which has been considered as an oxide.

Oxide of Gold may be obtained by adding a solution of potash to a solution of chloride of gold; the precipitate must be washed first with weak solution of potash, and then with water, and dried at a temperature of 100°. If this be regarded as a protoxide, that is, as consisting of 1 proportion of gold + 1 of oxygen, then the number 97 will represent gold, and this oxide will consist of 97 gold + 7,5 oxygen = 104,5.

Chloride of Gold.—When gold in a state of minute division is heated in chlorine, a compound of a deep yellow colour results, which consists of 97 gold + 33,5 chlorine. When acted upon by water, a *muriate* of gold is produced.

The action of iodine in gold has scarcely been examined.

Nitrate of Gold.—The nitric acid has scarcely any action upon gold, but it readily dissolves the oxide, forming a yellow styptic deliquescent salt.

Fulminating Gold.—This compound is obtained by adding ammonia to a solution of muriate of gold. It is a yellow powder, which, when gently heated, explodes with some violence. The results of its decomposition are metallic gold, water, and nitrogen.

Sulphuret of Gold is procured by passing sulphuretted hydrogen through an aqueous solution of muriate of gold. It is a black substance consisting of 97 gold + 30 sulphur.

Phosphuret of Gold is obtained by heating gold leaf with phosphorus, in a tube deprived of air. It is a grey substance of a metallic lustre, and consists of 97 gold + 20 phosphorus.

Silver.

Silver occurs in nature pure, and alloyed with gold, antimony, arsenic, and bismuth—also combined with sulphur, and with chlorine, and in some triple combinations, such as the sulphuret of arsenic and silver, and of antimony and silver.

To obtain pure silver, the metal as it occurs in commerce may be dissolved in nitric acid; solution of common salt is added to that of silver, as long as it causes a precipitate—which is to be washed, dried, and ignited with twice its weight of subcarbonate of potash—a button of pure silver is thus procured.

Silver is a white metal, and when in fusion, very brilliant. It melts at a cherry red heat, and is not oxidized by exposure to air.

Oxide of Silver may be procured by adding a solution of barytes to one of nitrate of silver; a grey powder is precipitated, which, when washed and dried, consists of 102 silver + 7,5 oxygen.

Chloride of Silver is obtained by adding solution of chlorine, or of muriatic acid, to nitrate of silver. It is white, and fusible by a gentle heat into a semi-transparent mass (Luna Cornea). It consists of 102 silver + 33,5 chlorine.

Fulminating Silver is a compound of ammonia and oxide of silver, more violent in its operation than fulminating gold.

Nitrate of Silver.—The nitric acid diluted with 3 or 4 parts of water readily oxidizes and dissolves silver, and by evaporation a crystallized nitrate of silver is obtained, consisting of 109,5 oxide of silver + 50,5 nitric acid.

Sulphuret of Silver is obtained by the action of sulphuretted hydrogen upon an aqueous solution of nitrate of silver; it is of a dark grey colour, and often found in silver mines. It consists of 102 silver + 15 sulphur.

Sulphate of Silver is a white salt which crystallizes in fine needles, very difficultly soluble in water. It is procured by adding nitrate of silver to sulphate of soda, and then falls as a white precipitate. It easily dissolves in sulphuric and nitric acids, and in ammonia. It consists of 109,5 oxide + 37,5 sulphuric acid.

Phosphate of Silver, a pale yellow compound obtained by pouring phosphoric acid into nitrate of silver. It is insoluble in water, but dissolves in phosphoric acid.

Carbonate of Silver is formed by adding solution of carbonate of potash to nitrate of silver. It is of a pale yellow colour, but, like most other salts of silver, blackens when exposed to light. It consists of 109,5 oxide + 20,7 acid.

Cyanuret of Silver.—A white compound obtained by adding prussiate (hydrocyanate) of potash to nitrate of silver.

Borate of Silver.—An insoluble white powder.

Platinum

Is found in small grains in South America, confined to alluvial strata: The pure metal may be obtained by dissolving crude platinum in nitro-muriatic acid, and precipitating by a solution of muriate of ammonia. This first precipitate is dissolved in nitro-muriatic acid, and again precipitated as before. The second precipitate is heated white hot, and pure platinum remains. It is a white metal, extremely difficult of fusion, and unaltered by the joint action of heat and air.

Oxide of Platinum is procured by adding excess of potash to muriate of platinum. It falls as a black powder, composed of 92 metal + 7,5 oxygen.

Chloride of Platinum may be formed by heating the muriate in close vessels. It has not been particularly examined.

Muriate of Platinum is obtained by evaporating the nitro-muriatic solution; it is acrid, deliquescent, and difficultly crystallizable. It forms a triple compound with ammonia, of difficult solubility.

Sulphuret of Platinum is formed by heating the finely divided metal with sulphur in close vessels. It is a black, brittle compound, and consists of 92 platinum + 15 sulphur.

The four following metals have been discovered in the ore of platinum by Dr Wollaston and Mr Tennant.

Palladium and Rhodium.

These metals are obtained as follows: Dissolve

crude platinum in nitro-muriatic acid, precipitate by sal-ammoniac, and filter. The filtered liquor may contain iron, copper, lead, gold, platinum, palladium, and rhodium. Immerse a plate of iron, which will precipitate all the above metals except iron; digest this precipitate in dilute nitric acid, which will dissolve the lead and copper; then in nitro muriatic acid, which takes up platinum, palladium, and rhodium; add to this solution some common salt, which forms triple compounds with the three metals. Alcohol dissolves two of these, and leaves the triple salt of rhodium; this is to be dissolved in water, and a plate of zinc immersed into the solution, which precipitates metallic rhodium.

Rhodium is characterized by the rose colour of many of its salts. It is not precipitated either by muriate or hydrosulphuret of ammonia.

The triple salts of palladium and of platinum may be decomposed by prussiate of potash, which throws down the former, and from which the metal may be obtained by ignition.

Palladium is a white metal, malleable and ductile.

Iridium.

When the ore of platinum is digested in nitro-muriatic acid, there remains a black powder, which, when alternately acted upon by muriatic acid and soda, is for the most part dissolved. The acid solution contains iridium, and by evaporation and exposure to heat, the metal is obtained. Its colour is that of platinum; it appears almost infusible. Its combinations have not been examined with precision.

Osmium.

Osmium is contained in the alcaline solution just alluded to. It may be obtained by distilling it with a little sulphuric acid. Its oxide passes over dissolved in water, from which solution it may be separated by mercury.

Osmium has a peculiar smell like new bread. Acids do not act upon it. Alcalies readily dissolve it. Tincture of galls added to its solution produces a vivid blue colour.

Mercury.

The principal ore of this metal is the sulphuret, or native cinnabar, from which the mercury is separated by distillation with quicklime, or iron filings.

Mercury is a brilliant white metal, with a tint of blue. It is liquid at all common temperatures, solid at 40^0, and gaseous at 670^0.

Mercury and Oxygen.—There are two oxides of mercury. 1. The black, or protoxyde, may be obtained by long agitation of the metal in contact with oxygen, or by washing the chloride of mercury (calomel) with hot lime-water. It is insipid, and consists of $190\ M + 7{,}5$ oxygen. 2. The red, or peroxide of mercury, is produced by exposing the metal heated nearly to its boiling point to the action of air. It becomes coated with red scales, spangles, and crystals, which consist of 190 mercury $+$ 15 oxygen.

Chlorides of Mercury.—This metal also forms two compounds with chlorine; the chloride or *calomel*, composed of one proportion of mercury $= 190 +$ one of chlorine $= 33.5$, and the bichloride or *corrosive sublimate*, consisting of one proportion of mercury and two of chlorine, or $190 + 67$. These compounds, and especially the former, are most important pharmaceutical preparations. In the London *Pharmacopœia*, they are very improperly termed submuriate and oxymuriate of mercury.

Chloride of Mercury, or calomel, is produced by exposing to heat, in proper subliming vessels, a mixture of common salt and sulphate of mercury. Upon the large scale, the following are the best proportions: 50 lbs. of mercury are boiled with 70 lbs. of sulphuric acid to dryness in a cast-iron vessel. 62 lbs. of the dry salt are triturated with $40\frac{1}{2}$ lbs. of mercury, until the globules disappear, and 34 lbs. of common salt are then added. This mixture is submitted to heat in earthen vessels, and from 95 to 100 lbs. of calomel are the result. It is to be washed in large quantities of distilled water, after having been ground to a fine powder.

Calomel is a white crystallizable compound, insoluble in water, and unaltered by exposure to air; long exposed to light, it becomes brown.

Bichloride of Mercury, or corrosive sublimate.—When mercury is heated in chlorine, the metal burns with a white flame, and, combining with the gas, produces a white sublimate of bichloride; but the following process is usually adopted for the preparation of this compound: 5 parts of sulphuric acid are boiled with 4 of mercury to dryness; the dry mass is reduced to powder, and mixed with 4 parts of common salt, and 1 of black oxide of manganese. This mixture is put into a glass subliming vessel, and gradually heated to redness. The bichloride rises in the form of a white semitransparent crystalline mass. Corrosive sublimate has a disgustingly nauseous and astringent flavour, and is highly poisonous. At the temperature of 60^0, it is soluble in 20 parts of water, and at 212^0 in about 3 parts. Alcohol dissolves nearly its own weight. With muriate of ammonia it produces a very soluble compound.

Mercury and Iodine produce a compound of a brilliant scarlet colour, or yellow with excess of mercury.

Mercury and Nitric Acid.—The results of the action of nitric acid upon mercury vary with the circumstances under which it has taken place. If excess of mercury be exposed to the action of dilute nitric acid, the metal is protoxidized, and the solution affords white prismatic crystals of an acrid and metallic taste. These are the *nitrate of mercury.* When put into water they are resolved into *supernitrate*, which dissolves, and into *subnitrate*, which is an insoluble yellow powder. The solution of nitrate of mercury furnishes a black precipitate of oxide with solution of potash, and a white precipitate of chloride with solution of common salt.

When nitric acid diluted with 4 parts of water is boiled on mercury, the acid being in excess, the metal is converted into peroxide, and a compound of nitric acid and peroxide of mercury, or an *oxynitrate of mercury* is formed. By evaporation irregular crystals, of a very acid taste, are obtained, which, by water, are resolved into a soluble *superoxynitrate*, and into an insoluble yellow *suboxynitrate*.

Mercury and Sulphur.—When these bodies are triturated together, a black powder results called formerly Ethiops mineral. When ten parts of mercury are heated in a matrass with one of sulphur, there is considerable action attended by ignition, and a violet coloured compound results, which affords, by sublimation, a crystalline mass, becoming, when reduced to powder, of a fine red hue. This is *Sulphuret of Mercury*, *Cinnabar*, or *Vermillion*. It is tasteless, insoluble in water, and consists of 190 M. + 30 S.

Mercury and Sulphuric Acid.—*Sulphate of Mercury* is an insoluble white salt, obtained by adding sulphuric acid to a solution of nitrate of mercury. *Oxysulphate of Mercury* is formed by boiling the metal with the acid; it is peroxidized and dissolved; sulphurous acid is evolved, and a white crystallized mass remains. When this salt is put into water it is resolved into a *Superoxysulphate*, and into an insoluble *Suboxysulphate* of a yellow colour, and formerly called Turpeth mineral.

Phosphuret of Mercury is formed by heating phosphorus strongly with calomel; it is of a brown colour. *Phosphate of Mercury* is obtained by adding phosphate of soda to nitrate of mercury; it is white and insoluble in excess of acid. The *Oxyphosphate of Mercury* is soluble in excess of acid.

Carbonate of Mercury.—Carbonate of potash furnishes a yellow precipitate in solution of nitrate of mercury.

Mercury and Cyanogen.—The compound hitherto called Prussiate of Mercury consists, according to M. Gay-Lussac, of 80 mercury + 20 cyanogen. This compound, when distilled with muriatic acid, affords the hydrocyanic (prussic) acid. (See M. Gay-Lussac's *Memoir Annales de Chimie*, T. 98, p. 144, ann. 1815.)

Lead.

The natural compounds of this metal are very numerous. The most important is the sulphuret, whence the pure metal is chiefly procured. It is also found combined with carbonic, sulphuric, phosphoric, arsenic, molybdic, and chromic acids, and with oxygen and chlorine. To obtain lead perfectly pure, it may be dissolved in nitric acid,—the solution evaporated to dryness,—the dry mass redissolved in water and crystallized;—the crystals heated strongly with charcoal afford the metal quite pure.

Lead is of a bluish white tint,—it melts at 600°, and by the united action of heat and air is readily converted into an oxide.

Oxides of Lead.—There are three oxides of lead. The *protoxide* (massicot) is the basis of the salts; it may be obtained by heating the nitrate of lead to redness in a close vessel. It is insipid and insoluble in water,—of a pale yellow colour, and when fused crystallizes on cooling in irregular scales (litharge). It is very soluble in potash and soda, and when in fusion it readily dissolves several of the earthy bodies. If it be considered as a protoxide consisting of one proportion of lead and one of oxygen, then the number 97 will represent lead, and it will consist of 97 L. + 7,5 oxygen.

If the protoxide be exposed to heat and oxygen, it gradually acquires a bright red colour, and is known under the name of Minium, or *deutoxide* of lead. This oxide, when exposed to nitric acid, is resolved into protoxide, which is dissolved, and into *peroxide*, which is an insoluble brown substance, consisting of 97 L. + 15 oxygen. Minium affords on analysis 97 L. + 11,25 oxygen, and may, therefore, be regarded as a definite compound of the protoxide and peroxide.

Lead and Chlorine.—Chloride of lead. When laminated lead is heated in chlorine, the gas is absorbed, and a chloride of lead results, composed of 97 L. + 33,5 C. The same substance is obtained by adding muriatic acid to nitrate of lead; it is white and fusible, and on cooling forms a horn-like substance (*plumbum corneum*). It dissolves in 22 parts of water at 60°.

Nitrate of Lead—obtained by dissolving the metal in dilute nitric acid, and evaporation. The salt crystallizes in tetraëdra and octoëdra. It is soluble in 8 parts of water at 212°. It consists of 104,5 oxide of lead + 50,5 nitric acid.

Lead and Sulphur readily combine and form a *sulphuret of lead*, composed of 97 L. + 15 S.

Sulphate of Lead is a white insoluble compound, containing 104,5 oxide of lead + 37,5 sulphuric acid. It is formed by adding dilute sulphuric acid to nitrate of lead.

Phosphate of Lead is a yellow insoluble compound obtained by adding phosphoric acid to nitrate of lead. It consists of 104,5 oxide + 25 acid.

Carbonate of Lead is an important compound, on account of its use in the arts; it is commonly called White Lead. It is formed by adding carbonate of potash to nitrate of lead, when a white precipitate falls, consisting of 104,5 oxide + 20,7 carbonic acid.

Nickel.

Nickel is found native, combined with arsenic, and with arsenic acid. It is procured pure by the following process: Dissolve the metal sold under the name of nickel in dilute nitric acid to saturation, and evaporate to dryness; redissolve in water, and add nitrate of lead sufficient to precipitate the arsenic acid; filter, and immerse a plate of iron to separate copper; filter again, and add solution of carbonate of potash; wash the precipitate thus occasioned, and put it, while moist, into liquid ammonia, which dissolves the oxides of nickel and cobalt, leaving impurities to be separated by a filter; add potash to the ammoniacal solution, which precipitates the oxide of nickel, and which, by ignition with charcoal, affords a globule of the pure metal. Nickel is a white metal, which acts upon the magnetic needle, and is itself capable of becoming a magnet. It is very difficultly fusible, but absorbs oxygen readily when heated red-hot.

Oxide of Nickel is obtained by adding potash to the solution of the nitrate—a precipitate falls of a pale green colour, which is a *hydrate* or compound of oxide of nickel with water,—this heated to redness, affords a grey oxide, consisting of 55,5 nickel + 15 oxygen.

When nickel is heated in chlorine, a *chloride* re-

sults. This compound may also be obtained by heating muriate of nickel to redness in a glass tube,—a yellow scaly body is obtained, consisting of 55,5 nickel + 67 chlorine.

Nitrate of Nickel is a deliquescent difficultly crystallizable salt. The *sulphate* may be formed by dissolving the oxide in dilute sulphuric acid; it crystallizes in four-sided prisms of a beautiful grass-green. (For an elaborate account of the combinations of nickel, see *Annales de Chimie*, 1816.)

Arsenic.

Arsenic exists in nature nearly pure, and frequently occurs combined with other metallic substances.

The pure metal is obtained by heating a mixture of charcoal and *white arsenic* in a tube or retort,—it sublimes in small brilliant scales. Arsenic is a very inflammable, fusible, and volatile metal, and when heated in contact with the air, produces white fumes of a peculiar alliaceous odour.—It is highly poisonous in all its combinations.

Arsenic and Oxygen combine in two proportions, and produce compounds which have acid properties, —they have consequently been termed the arsenious and arsenic acids.

Arsenious Acid or *White Arsenic* is chiefly obtained by sublimation from certain ores, especially those of cobalt. It is met with in commerce as a semitransparent brittle body, of an acrid nauseous taste, soluble in 80 parts of water at 60°. The solution reddens vegetable blues,—it is equally soluble in alcohol. It is composed of 45 arsenic + 15 oxygen. It combines with metallic oxides, and produces a class of salts which have been termed arsenites. Some of these are produced by adding the solution of white arsenic to that of the other metallic oxide; others are best formed by adding solution of arsenite of potash to the other metallic salts.

Arsenic Acid is obtained by distilling four parts of nitric acid and one of arsenious acid to dryness. The white mass which remains is more sour and soluble than the white arsenic, and it constitutes a different set of salts, which are called arseniates. It consists of 45 arsenic + 22,5 oxygen.

The arsenious acid forms uncrystallizable compounds with the alcalies. The *arsenite of ammonia* is easily formed by digesting finely powdered white arsenic in solution of ammonia. The arsenites of potash and soda may be formed in the same way.

The soluble *arseniates*, on the other hand, are crystallizable. The *arseniate of ammonia* forms rhomboidal crystals. Neither the salts of gold nor those of platinum furnish any precipitates with the acids of arsenic, nor with the arseniate or arsenite of potash. Silver is precipitated white by arsenite of potash; but the solution of arsenious acid renders solution of nitrate of silver slightly turbid only. Arsenic acid, on the contrary, produces a copious reddish brown precipitate in solution of nitrate of silver, which is *arseniate of silver*. The arsenious acid forms dirty white precipitates in the solutions of nitrate and oxynitrate of mercury. The arsenic acid produces no precipitate in either, but the arseniate of potash a yellowish precipitate in both.

Nitrate of lead furnishes no precipitate with arsenious acid: but the arsenite of potash forms a white *arsenite of lead*. The arsenic acid, and the arseniate of potash, added to solution of nitrate of lead, instantly form insoluble white precipitates of *arseniate of lead*.

The *arseniate of nickel* is a very pale green precipitate obtained by adding arseniate of potash to nitrate of nickel. The *arsenite* of nickel has the same appearance.

Arsenic and Chlorine act upon each other with great energy,—the metal burns, the gas is absorbed, and a *chloride of arsenic* results, having at first the appearance of white fumes, which condense into a thick fluid, volatile and caustic, and which at a low temperature congeals. (Butter of arsenic.) It consists of 45 arsenic + 67 chlorine. When mixed with water it affords *muriate of arsenic*.

Arsenic and Iodine, when heated together, produce a red sublimate, which, acted upon by water, furnishes hydriodic and arsenic acids.

Arsenic and Hydrogen.—When an alloy of arsenic and potassium is thrown into water, a brown *hydruret of arsenic* results. When arsenic is presented to nascent hydrogen, as when a mixture of white arsenic and zinc filings is exposed to the action of dilute sulphuric acid, the metal is dissolved by the gas, and we thus obtain the *arsenuretted hydrogen gas*. It may be collected and preserved over water. The composition, and consequently the specific gravity of this gas, vary,—and no accurate results have hitherto been obtained concerning it. When inflamed in contact with air, it produces white oxide of arsenic and water, and hydruret of arsenic is deposited upon the vessels. When chlorine is allowed to bubble up into this gas standing over water, inflammation frequently occurs,—hydruret of arsenic is deposited, and chloride of arsenic formed. When decomposed, one volume of arsenuretted hydrogen appears to afford 1,5 volumes of hydrogen.

There are two *sulphurets of arsenic*, the one of a bright red colour, called Realgar,—the other yellow, and known in commerce under the name of Orpiment.

The sulphuric acid dissolves the arsenious acid, and forms a difficultly soluble *sulphate of arsenic*.

Alloys.—With gold, platinum, and silver, arsenic forms brittle compounds of comparatively easy fusion,—it amalgamates with mercury, produces a brittle alloy with lead, and with nickel forms a reddish compound. The latter metal is indeed generally found alloyed with arsenic.

Molybdenum.

The sulphuret is the most common natural compound of this metal. To procure the metal the native sulphuret is powdered and exposed under a red-hot muffle, till converted into a grey powder, which is to be digested in ammonia, and the solution filtered and evaporated to dryness. The residuum is dissolved in nitric acid, reevaporated to dryness, and violently heated with charcoal. The metal is of a whitish grey colour, and of excessively difficult fusion.

Molybdenum and Oxygen, when exposed to heat, and oxygen molybdenum is acidified, a white crystalline sublimate of *Molybdic Acid* being formed.

There are two other compounds with oxygen—the one black, obtained by heating molybdic acid with charcoal; the other blue, and procured by immersing tin in solution of molybdic acid.—The black oxide consists of

	44 M. + 7,5. oxy.
the blue (molybdous acid)	44 M. + 15.—
the white (molybdic acid)	44 M. + 22,5.

These acids combine with certain bases forming molybdites and molybdates. Molybdate of silver, of mercury, of lead, and of nickel, may be procured by adding molybdic acid to the respective nitrates of those metals.

Sulphuret of Molybdenum is a sectile compound of a metallic lustre, composed of 44 M. + 30 S.

Chrome.

The native combinations of chrome are the oxide, and the chromates of lead and iron.

By violently igniting the oxide with charcoal a white, brittle, and very difficultly fusible metal is obtained.

Chrome and Oxygen.—The *Oxide of Chrome* is of a green colour, and may be procured by exposing chromic acid to a red heat.

Chromic Acid may be obtained by digesting native chromate of lead in fine powder, in carbonate of potash. A chromate of potash is produced, to which sulphuric acid is added; by evaporation sulphate of potash and crystals of chromic acid are obtained. Chromic acid is of a red colour, and very soluble in water.

The other combinations of chrome are very imperfectly known.

Tungsten.

There is a mineral called Tungsten, which is a native tungstate of lime, and another called Wolfram, consisting of tungstic acid, iron, and manganese. To obtain the metal, either of its oxides are violently ignited with charcoal—in colour it resembles iron—it is hard and brittle.

Oxides of Tungsten.—This metal unites in two proportions with oxygen. The black oxide may be obtained by igniting the peroxide with charcoal. Its properties have not been investigated.

The peroxide, or *Tungstic Acid,* is obtained from native tungstate of lime, which is fused with four times its weight of subcarbonate of potash. The fused mass is dissolved in water, and nitric acid added to the filtered solution which precipitates the tungstic acid. This body is of a yellow colour—it unites with the alcalies, and forms soluble salts.

Columbium.

This metal was first discovered by Mr Hatchett in a mineral from North America. It is found combined with the oxides of iron and manganese, and also with yttria, in the minerals called tantalite and yttro-tantalite. The peroxide of columbium is almost insoluble in nitric and sulphuric acids, but when freshly precipitated it dissolves in oxalic, tartaric, and nitric acids, and very readily in potash.

Antimony.

This metal is found native, but its principal ore is the *Sulphuret,* from which pure antimony may be obtained by the following process: Mix three parts of the powdered sulphuret with two of crude tartar, and throw the mixture by spoonfuls into a red-hot crucible; then heat the mass to redness, and a button of metal will be found at the bottom of the crucible. Reduce this button to fine powder, and dissolve it in nitro-muriatic acid—pour this solution into water, which will occasion the precipitation of a white powder, which is to be mixed with twice its weight of tartar, and exposed to a dull red heat in a crucible. The button now obtained is pure antimony.

Antimony is of a silvery white colour, brittle and crystalline in its ordinary texture. It fuses at 800° Fahrenheit.

Antimony and Oxygen.—These bodies form two well defined compounds, the history of which is of great importance to the pharmaceutical chemist.

The *Protoxide of Antimony* is thus obtained: To 200 parts of sulphuric acid add 50 parts of powdered metallic antimony. Boil the mixture to dryness, wash the dry mass first in water, and then with a weak solution of subcarbonate of potash, a white powder remains, which, when thoroughly washed with hot water, is *Protoxide of Antimony.*

This protoxide exists in all the active antimonial preparations—in emetic tartar, kermes, glass of antimony, golden sulphuret, &c. It consists of 85 A. + 15 oxygen. It is fusible and volatile at a red heat, decomposed by sulphur and charcoal; and, when acted on by nitric acid, is converted into peroxide.

Peroxide of Antimony is procured by acting upon the powdered metal by excess of hot nitric acid. It is of a yellow white, difficultly fusible, and does not form soluble salts with acids. It consists of 85 ant. + 22,5 oxygen. The diaphoretic antimony of old Pharmacopœiæ consisted of this oxide.

Antimony and Chlorine combine in one proportion only to produce the chloride of antimony. (Butter of Antimony.) The powdered metal takes fire when thrown into the gas, and a compound, at first liquid, but afterwards concreting, is formed. It may also be produced by the distillation of antimony and bichloride of mercury, or by heating the solution of protoxide of antimony in muriatic acid. It consists of 85 A. + 67 C. When water is added to the chloride of antimony, a mutual decomposition ensues, and protoxide of antimony and muriatic acid result.

Sulphuret of Antimony is easily formed by fusing the metal with sulphur. It consists of 85 A. + 30 S.

Sulphate of Antimony.—When sulphuric acid is boiled upon finely powdered antimony, the metal is oxidized, and an acid sulphate and a subsulphate of antimony are the results. In both these salts the metal is in the state of protoxide.

Hydrosulphuretted Oxide of Antimony.—This compound has long been known under the name of *Kermes Mineral.* It is commonly prepared as follows: Equal parts of sulphuret of antimony and common potash are fused together; the resulting mass is finely powdered, and boiled in ten times its weight

of water. The liquor is filtered while hot; and, during cooling, it deposits *kermes*. The mother liquor of *kermes* deposits a copious yellowish red precipitate upon the addition of dilute sulphuric acid, which, when washed and dried, is known under the name of golden sulphur of antimony. It is improperly called in the London Pharmacopœia *antimonii sulphuretum præcipitatum*.

In forming these compounds, the following changes seem to have taken place. The sulphuret of antimony and potash acts upon the water, a portion of which is decomposed; hydrogen is transferred to the alcaline sulphuret to form hydrosulphuret of potash; hydrogen and oxygen unite to the sulphuret of antimony, producing a hydrosulphuretted oxide of that metal (*kermes*), which remains dissolved in the hot alcaline hydrosulphuret, and of which one portion is precipitated as that solution cools. When dilute sulphuric acid is added, the hydrosulphuret of potash is decomposed, sulphate of potash is formed, and sulphur and sulphuretted hydrogen are liberated; the sulphur falls in combination with the *kermes*, producing the *golden sulphur*, or sulphuretted hydrosulphuret.

Uranium.

The oxide and the sulphuret are the principal native combinations of uranium. To obtain the metal from the sulphuret, it is heated in a muffle, and digested in nitro-muriatic acid; the oxide of uranium is precipitable from this solution by potash; and, when exposed to an intense heat with charcoal, it affords the metal. It is grey, and extremely difficultly fusible.

Very few experiments have hitherto been made upon this metal. The oxide precipitated from its nitric solution by alcalies is yellow, but by heating with charcoal it becomes black. The uranitic ore, called by the Germans *Uran glimmer*, is a hydrate of the yellow oxide. The salts of uranium have a yellow colour and an astringent metallic taste. Potash forms in their solutions a yellow precipitate, and carbonate of potash a white precipitate; both these precipitates are redissoluble in excess of alcali.

Cerium.

This metal has been obtained by Hisinger and Berzelius from a mineral found at Bastnas in Sweden, to which they have given the name of *cerite*. The ore is calcined, pulverised, and digested in nitro-muriatic acid. To the filtered solution, saturated with potash, oxalic acid is added, which occasions a precipitate; this, when dried and ignited, is *oxide of cerium*.

There are two oxides of cerium, the red or *protoxide*, and the white or *peroxide*. The salts of cerium have a sweetish taste. Those formed with the protoxide are colourless, those with the peroxide are yellow.

Cobalt.

The native combinations of cobalt are the oxide, the compound of the metal with iron, nickel, arsenic, and sulphur. It is also found combined with arsenic acid.

To obtain the pure metal, the substance called zaffre, which is an impure oxide of cobalt, may be detonated three or four times with half its weight of nitre, then washed in hot water, and the residue digested in nitric acid. The nitric solution, when filtered and evaporated, yields an oxide, which, by ignition with charcoal, affords cobalt. Cobalt is of a grey colour, brittle, and difficultly fusible.

Cobalt and Oxygen unite in two proportions. The *protoxide* is formed by adding potash to the nitrate, and drying the precipitate; it appears reddish black. By exposure to heat and air, it absorbs an additional portion of oxygen, and is thus converted into black *peroxide*. The protoxide, when recently precipitated and moist, is blue; and, if left in contact of water, becomes a red *hydrate*.

Cobalt, when heated in chlorine, burns; but the *chloride of cobalt* has not been examined.

The salts of cobalt all contain the protoxide, and are of a red colour; the alcalies produce in them bluish precipitates, which redissolve in excess of ammonia. Prussiate of potash forms a grass-green precipitate; and phosphoric, carbonic, arsenic, and oxalic acids, form insoluble precipitates of a red colour.

Muriate of Cobalt is a deliquescent salt, of a blue green colour; when a little diluted, it becomes pink; the pale pink solution, when written with, is scarcely visible; but, if gently heated, the writing appears in brilliant green, which soon vanishes as the paper cools, in consequence of the salt absorbing the aërial moisture.

With nitric acid, the oxide of cobalt furnishes a red deliquescent *nitrate of cobalt*.

Sulphuret of Cobalt is formed by heating the oxide with sulphur.

Sulphate of Cobalt forms red rhombic crystal.

Phosphuret of Cobalt is a white brittle compound.

Phosphate of Cobalt may be formed by double decomposition, as by adding phosphate of soda to muriate of cobalt; it is insoluble; of a purple colour; and, if mixed with eight parts of gelatinous alumina, and heated, it produces a beautiful blue, which may sometimes be employed by painters as a substitute for ultramarine.

Titanium.

Titanium exists in the state of oxide, in two minerals—in titanite and in menachanite. The metal may be obtained from the former by fusion with potash; the fused mass, washed with water, leaves oxide of titanium, containing a little iron; it is to be dissolved in muriatic acid, and precipitated by oxalic acid. The oxalate affords the metal by intense ignition with charcoal.

Titanium is of the colour of copper. It is oxidized by exposure to heat and air, and is said to be susceptible of three degrees of oxidizement, the colours of the oxides being blue, red, and white.

Bismuth

Is found native, combined with oxygen, and with arsenic and sulphur. The metal may be obtained pure by dissolving the bismuth of commerce in nitric acid; water is added to the nitric solution, which separates oxide of bismuth. This oxide is easily re-

 duced in the usual way. Bismuth is a brittle brilliant white metal, with a slight tint of red; it fuses at 476°, and always crystallizes on cooling. When exposed to heat and air it oxidizes, forming the *white oxide.* It consists of 66,5 bismuth + 7,5 oxygen.

Chloride of Bismuth is procured by heating the metal in the gas. It is a fusible volatile substance, decomposed by water; consisting of 66,5 B + 33,5 C.

Nitrate of Bismuth crystallizes in small four sided prisms, consisting of 74 oxide + 50,5 acid. It is decomposed by water, and the oxide of bismuth is thrown down in the form of fine white powder. (Magistery of Bismuth, Pearl white, &c.)

Sulphuret of Bismuth is of a bluish colour and metallic lustre; it consists of 66,5 B. + 15 sulphur.

Sulphate of Bismuth consists of 74 oxide + 37,5 acid; it is a white compound insoluble in, but decomposed by water, which converts it into a subsulphate and supersulphate.

Bismuth forms alloys, some of which are remarkable for their fusibility. With gold, platinum, and silver, it forms brittle compounds. A compound of 8 parts of bismuth, 5 of lead, and 3 of tin, liquifies at 212°; it is called *fusible metal.* The addition of 1 part of quicksilver renders it yet more fusible.

Copper.

This metal is found native, and in various states of combination. Of its ores, the oxide, chloride, sulphuret, sulphate, phosphate, carbonate, and arseniate, are the most remarkable. The metal may be obtained perfectly pure by dissolving the copper of commerce in muriatic acid; the solution is diluted, and a plate of iron is immersed upon which the copper is precipitated; it may be fused into a button.

Copper has a fine red colour and much brilliancy; it is very malleable and ductile, and has a peculiar smell when warmed or rubbed. It melts at a cherry red or dull white heat.

Copper and Oxygen.—There are two oxides of copper. The *red* or *protoxide* occurs native. It may be formed artificially, by dissolving a mixture of metallic copper, and peroxide of copper, in muriatic acid. When potash is added to this solution, a *hydrated protoxide* of an orange colour falls; if quickly dried out of the contact of air, it becomes of a red brown; it consists of 60 copper + 7,5 oxygen. The *peroxide* of copper is procured by precipitating nitrate of copper by potash, washing the precipitate, and exposing it to a red heat. It is black, and consists of 60 copper + 15 oxygen.

Copper and Chlorine.—Gaseous chlorine acts upon copper with great energy, and produces two chlorides, the one a fixed fusible substance, which is the chloride, consisting of 1 proportion of copper = 60 + 1 proportion of chlorine = 33,5. The other a volatile yellow substance, which is a bichloride, and contains 60 copper + 67 chlorine. These compounds furnish, with water, a solution of muriate of copper.

Nitric Acid, diluted with three parts of water, rapidly peroxidizes copper, forming a bright blue solution, which affords deliquescent prismatic crystals or evaporation. It consists of 75 oxide + 50,5 acid. Potash forms, in this solution, a bulky blue precipitate of *hydrated peroxide of copper.*

If ammonia be added to solution of nitrate of copper, it occasions also a precipitate of hydrate, but if it be added in excess, the precipitate is redissolved, and a triple compound produced. Ammonia also dissolves the peroxide of copper; forming a crystallizable compound of an intense blue colour.

Copper and Sulphur.—There are two sulphurets of copper, both of which exist native; the one is black, and may be formed artificially, by heating a mixture of copper filings and sulphur; as soon as the latter melts a violent action ensues, the copper becomes red hot, hydrogen escapes, and a black brittle body is formed, consisting of 60 copper + 15 sulphur.

The *Bisulphuret* is a common ore of copper called *Pyrites.* It consists of 60 copper + 30 sulphur, and is of a golden yellow colour.

Copper and Sulphurous Acid—Sulphite of Copper may be obtained by passing sulphurous acid into water, through which peroxide of copper is diffused. Small red crystals are formed, composed of protoxide of copper and sulphurous acid.

Copper and Sulphuric Acid—Oxisulphate of Copper—Blue Vitriol.—This salt is formed by dissolving peroxide of copper in sulphuric acid; it crystallizes in rhomboidal prisms of a fine blue colour. It is produced upon a large scale, by exposing roasted sulphuret of copper to air and moisture. It consists of 75 peroxide + 75 sulphuric acid; when crystallized, it contains 5 proportions of water, and consequently its composition will stand thus:

1 proportion peroxide,	75.
2 proportions sulphuric acid,	75.
5 proportions of water,	42.5
	192.5

By cautiously adding ammonia to a solution of the foregoing salt, a subsulphate of copper is precipitated, consisting of 150 oxide + 37,5 acid. The alcalies precipitate hydrated peroxide from the solution of this salt, and excess of ammonia forms a triple sulphate.

Phosphorus and Copper form a grey brittle *phosphuret.*

Phosphate of Copper may be formed by mixing solution of sulphate of copper with phosphate of soda; it is a blue green insoluble powder, composed of 75 oxide + 25 acid.

Carbonate of Copper, artificially prepared by adding carbonate of potash to sulphate of copper, is a green insoluble compound, containing 75 oxide + 20,7 acid. *Verditer* is a mixture of this carbonate with chalk; it is obtained by adding chalk to solution of nitrate of copper.

Many of the alloys of copper are important. With gold it forms a fine yellow ductile compound, used for coin and ornamental work. Sterling or standard gold consists of 11 gold + 1 copper. The specific gravity of this alloy is 17,157. With silver it forms a white compound, used for plate and coin. Lead and copper require a high red heat for union—the alloy is grey and brittle.

Tellurium.

The ores of tellurium are, 1. *Native*, in which the metal is combined with iron and a little gold. 2. Graphic ore, which consists of tellurium, gold, and silver. 3. Yellow ore, a compound of tellurium, gold, lead, and silver; and 4. Black ore, consisting of the same metals with copper and sulphur.

The metal is extracted from these ores by precipitating their diluted nitro-muriatic solution by potash, which is added in excess; the clear liquor is poured off and saturated with muriatic acid, which affords a precipitate of oxide of tellurium. This heated in a glass retort with charcoal furnishes the metal. Tellurium is of a bright grey colour, brittle, easily fusible, and very volatile. It burns with a blue flame, and produces a yellowish *oxide*, composed of 37 tell. + 7,5 oxy.

Chloride of Tellurium is white, and consists of 37 T. + 33,5. C.

Tellurium combines with hydrogen, producing *Telluretted hydrogen gas*. The soluble salts of tellurium furnish white precipitates, when neutralized by alcalies, which are soluble in excess either of the solvent or precipitant.

Iron.

The most important native combinations of iron, whence the immense supplies for the arts of life are drawn, are the oxides. Iron is also found combined with sulphur, and with several acids; it is so abundant that there are few fossils free from it. It is also found in some animal and vegetable bodies. Iron is a metal of a blue white colour, very malleable and ductile, and fusible at a white heat.

Iron and Oxygen.—Exposed to heat and air, iron quickly oxidizes. It unites with oxygen in at least two proportions. The *protoxide* may be procured by precipitating a solution of sulphate of iron by potash, washing the precipitate out of the contact of air, and drying it at a red heat. It is black, and consists of 52 iron + 15 oxygen.

When this oxide is boiled in nitric acid, and precipitated by ammonia, washed, and dried at a low red heat, it increases in weight, and acquires a brown colour. This is the *peroxide* composed of 52 iron + 22,5 oxygen. These oxides form distinct salts with the acids. The salts containing the black oxide are of a green colour, mostly crystallizable, become reddish brown by exposure to air, are insoluble in alcohol, and their solutions absorb nitric oxide gas and become of a deep olive colour.

The salts with the brown oxide do not crystallize; they are brown, soluble in alcohol, and do not absorb nitric oxide.

The alcalies precipitate hydrated oxides from these solutions.

Iron and Chlorine unite in two proportions—the chloride may be obtained by evaporating green muriate of iron to dryness, and exposing the residuum to a red heat. A grey brittle substance is formed, consisting of one proportion of iron and two of chlorine 52 + 67.

When iron wire is heated in chlorine it burns with a red light, and produces a compound which rises in beautiful brown scales. It is the *perchloride of iron*, and consists of one proportion of iron and three of chlorine 52 + 100,5. The chloride and perchloride of iron produce muriate and oxymuriate of iron when acted upon by water. These salts are both deliquescent and uncrystallizable.

Iodine and Iron readily form a brown compound, fusible at a red heat, and which, when put into water, forms a hydriodate of a green colour.

The *nitric acid* dissolves the protoxide and peroxide of iron, and produces a green nitrate and a red oxynitrate, neither of which are crystallizable.

Sulphur and Iron.—There are two sulphurets of iron—the black *sulphuret* is composed of 52 iron + 30 sulphur; and the yellow sulphuret, or *bisulphuret*, of 52 iron + 60 sulphur. The former compound is produced by melting sulphur with iron filings; it exists in nature under the name of magnetic pyrites—the bisulphuret is exclusively a natural product, very abundant, and called iron pyrites.

Sulphates of Iron.—The sulphuric acid with the protoxide of iron forms a salt which crystallizes in green rhomboidal prisms, of a styptic taste, soluble in twice their weight of cold water. This salt is called *Copperas* or *green vitriol*, and is often prepared by exposing roasted pyrites to moisture. It consists of one proportion of protoxide = 67 + two proportions of acid = 75. The *oxysulphate of iron* is obtained by dissolving the moist red oxide in dilute sulphuric acid—it does not crystallize, but affords, by evaporation, a red deliquescent mass, consisting of 1 oxide + 3 sulph. acid or 74,5 oxide + 112,5 sul. acid. It is formed in the mother waters of the sulphate.

Phosphuret of Iron may be formed by dropping phosphorus into a crucible containing red-hot iron wire; it is a brittle grey compound, and acts upon the magnet.

Phosphates of Iron.—These are both insoluble, and may be formed by adding solution of phosphate of soda to sulphate and oxysulphate of iron. The phosphate of iron is of a pale blue colour; the oxyphosphate is white.

Iron and Carbon.—The different kinds of cast iron contain more or less carbon, which materially affects their properties. Steel and plumbago are *carburets of iron*.

Carbonic Acid may be combined with the *protoxide of iron*, by adding carbonate of potash to sulphate of iron; a green precipitate of carbonate of iron falls, which, exposed to air, becomes brown, and evolves carbonic acid.

Hydrocyanic (Prussic) Acid may be united by double decomposition with the oxides of iron, as by adding the prussiate of potash to the sulphate and oxysulphate. The former affords a white, the latter a fine blue precipitate, of hydrocyanate or prussiate of iron. (*Prussian blue.*)

The alloys of iron, with the metals hitherto described, are not important.

Tin.

The native oxide is the principal ore of tin; the metal is obtained by heating it to redness with charcoal. Tin has a silvery white colour; it is malleable, though sparingly ductile. It melts at 440°,

and by exposure to heat and air is gradually converted into a white *peroxide*.

Protoxide of Tin is obtained by precipitating muriate of tin by ammonia; it falls in the state of hydrate; when dried, it is of a grey colour, and undecomposable by heat. It dissolves in the alcalies,—exposed to heat and air, it passes into the state of *peroxide*.

Peroxide of Tin is formed by treating the metal with nitric acid; there is a violent action attended by the formation of nitrate of ammonia. It dissolves in the alcalies, and hence some chemists have called it *stannic acid*. This is the *native* oxide.

The number representing tin is 55. The protoxide consists of 55 tin + 7,5 oxygen. The hydrate of 62,5 oxide + 8,5 water; and the peroxide of 55 tin + 15 oxygen.

Chloride of Tin is procured by heating together an amalgam of tin and calomel; it is a grey semi-transparent crystalline solid, which dissolves in water, forming a muriate of tin; it consists of 55 tin + 33,5 chlorine.

If tin be heated in chlorine, or if amalgam of tin be distilled with corrosive sublimate, a *bichloride* is obtained; it is a transparent colourless fluid, and when poured into water is instantly converted into oxymuriate of tin. It consists of 55 tin + 67 chlorine. It was formerly called Libavius's fuming liquor; it exhales fumes when exposed to a moist air, and produces muriatic acid and oxide of tin.

The muriate of tin used by dyers may be obtained by boiling one part of tin with two of muriatic acid. This solution quickly absorbs oxygen from the air and from several compounds, and if added to metallic solutions, revives or deoxidizes them. With solution of gold, it produces a purple precipitate used in painting porcelain. (*Purple of Cassius.*) It crystallizes in small deliquescent needles. With infusion of cochineal, it produces a crimson precipitate. The *oxymuriate of tin* (muriate containing the peroxide) may be formed by dissolving the metal in nitro-muriatic acid, or by adding water to the bichloride, or by exposing the muriate to air. It does not occasion precipitates in other metallic solutions, and produces a scarlet with cochineal.

Nitrate of Tin may be formed by acting upon the metal by dilute nitric acid, a yellow solution which will not crystallize is obtained,—exposed to air, it absorbs oxygen, and peroxide of tin precipitates.

Tin and Sulphur.—There are two sulphurets of tin. That containing 1 proportion of metal + 1 of sulphur may be procured by heating tin with sulphur; it is of a bluish colour, and crystallizes in long needles. The *bisulphuret* is of a bright golden yellow colour, and flaky structure. (*Ausum musivum.*) It is formed by heating peroxide of tin with sulphur. These sulphurets consist respectively of 55 tin + 15 sulphur, and 55 tin + 30 sulphur.

Sulphate of Tin.—When tin is boiled in sulphuric acid, a solution is obtained which deposits white acicular crystals.

Hydrosulphuretted Oxide of Tin is yellow brown.

Many of the *alloys* of tin are useful. With copper it forms bronze, gun-metal, and bell-metal; and with iron, a white compound known under the name of *tin plate*.

Zinc.

Zinc is found in the state of oxide and of sulphuret. It may be obtained pure by dissolving the zinc of commerce in dilute sulphuric acid, and immersing a plate of zinc for some hours in the solution, which is then filtered, decomposed by subcarbonate of potash, and the precipitate ignited with charcoal.

Zinc is a bluish white metal, malleable at 300°, but very brittle when its temperature approaches the point of fusion, which is about 680°.

Oxide of Zinc is obtained by heating the metal exposed to air. At a red heat it inflames, burns with a bright flame, and is converted into a white flocculent substance, formerly called *Pompholix*, *nihil album*, and *Philosopher's wool*. It consists of 33 zinc and 7,5 oxygen. This oxide is white, tasteless, and soluble in the alcalies.

Chloride of Zinc is formed by heating leaf zinc in chlorine. It is a volatile fusible compound, producing a *muriate of zinc* by the action of water. It consists of 33 zinc + 33,5 chlorine.

Iodine and Zinc readily combine, and produce a fusible, volatile, and crystalline compound, which, when exposed to air, deliquesces into *hydriodate of zinc*.

Sulphuret of Zinc exists native under the name of *Blende*. It may be formed artificially by heating oxide of zinc with sulphur, and is then of a yellow brown colour. It consists of 33 zinc + 15 sulphur.

Sulphate of Zinc.—The metal is readily oxidized and dissolved by dilute sulphuric acid, hydrogen gas is given off, and a transparent colourless solution of sulphate of zinc results, which, by evaporation, affords crystals in the form of four-sided prisms, terminated by four-sided pyramids.

This salt is soluble in 2.5 parts of water at 60°. It consists of 1 proportion of oxide = 40,5 + 1 proportion of acid = 37,5. Its crystals contain 7 proportions of water = 59,5. Sulphate of zinc is prepared for the purposes of the arts from the native sulphuret, and is usually in the form of a white amorphous mass called *white vitriol*.

Phosphuret of Zinc is a brilliant lead-coloured compound.

Phosphate of Zinc is not crystallizable. It may be obtained by dissolving zinc in phosphoric acid and evaporation to dryness.

Carbonate of Zinc occurs native, forming one of the varieties of calamine.

Zinc forms with copper the very useful alloy called *brass*.

Manganese.

The common ore of manganese is the black or peroxide, which is found native in great abundance.

The metal may be procured by exposing the protoxide mixed with charcoal to an intense heat. It is of a bluish white colour, very brittle, and difficult of fusion. When exposed to air, it becomes an oxide.

Manganese and Oxygen.—There are two definite oxides of manganese. The *protoxide* may be obtained by digesting the native black oxide in muriatic acid. Chlorine is abundantly evolved, and the hydrogen of the muriatic acid unites with part of the oxygen of the oxide to produce water. The metal

thus partly deoxidized, is dissolved by the remaining muriatic acid, forming a *muriate of manganese.* Iron is almost always present, which may be easily separated by neutralizing the muriatic solution with ammonia. The oxide of iron is directly precipitated, but the oxide of manganese remains in solution, and may be separated by *excess* of ammonia.

The solutions of manganese furnish a white precipitate with the alcalies, which is a *hydrated oxide of manganese*, and which, when dried in close vessels, acquires a deep olive colour, and is the protoxide. It consists of 56,5 manganese $+$ 15 oxy. and the hydrate contains 71,5 oxide $+$ 17 water.

When this oxide is heated in contact with oxygen, it becomes deep brown, and is thus converted into the *peroxide*, which consists of 56,5 mang. $+$ 22,5 oxygen. This peroxide is not soluble in acids.

Manganese and Chlorine.—By burning the metal in chlorine, or by exposing muriate of manganese to a strong heat, a pink semitransparent flaky substance is obtained, consisting of 56,5 M. $+$ 67 C.

Manganese and Sulphur appear unsusceptible of combination.

Sulphate of Manganese is formed by dissolving the protoxide in the acid, or by boiling in it the peroxide, in which case oxygen is evolved. There are two sulphates. The one which is neutral is of a pink colour, the other, acid, is white. They crystallize in rhomboidal prisms.

Phosphuret of Manganese is of a blue white metallic lustre, and considerably inflammable.

Phosphate of Manganese is precipitated in the form of a white insoluble powder, by adding phosphate of soda to muriate of manganese.

Carbonate of Manganese is white, insipid, and insoluble in water.

Potassium.

The body known under the name of caustic potash is a hydrated oxide of this metal. It is decomposed at a white heat by the action of iron in the following manner: A sound and perfectly clean gun-barrel is bent, as shown in the annexed sketch. It

Fig. 1.

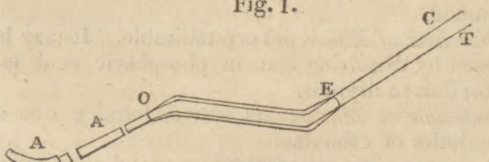
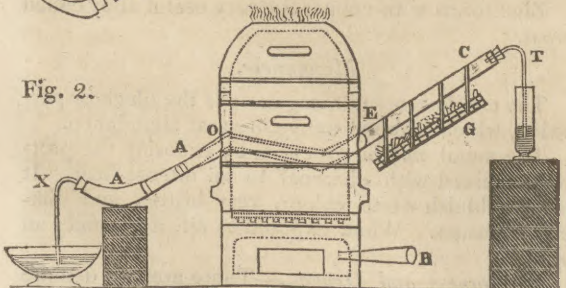


Fig. 2.



is then covered with an infusible lute between the letters O and E (fig. 1.), and the interior of the luted part is filled with clean iron turnings. Pieces of fused potash are then loosely placed in the barrel between E and C. AA is a copper tube and small receiver which are adapted to the extremity O, and to each other, by grinding. This apparatus is next transferred to the furnace, arranged, as shown in fig. 2. X and T representing two glass tubes dipping into mercury. The furnace is supplied with air by a good double bellows entering at B, and a small wire basket (G) is suspended below the space E C. The part of the barrel in the furnace is now cautiously raised to a white heat, and the escape of air by the tube X shows that all is tight. Some burning charcoal is then put at the end (E) of the cage G, which causes a portion of potash to liquefy and fall into the low part of the barrel upon the iron. Hydrogen gas instantly escapes by the tube X, and attention must now be had to keep the copper tubes (AA) cool, by laying wet cloths upon them. When the evolution of gas ceases, fresh charcoal is placed under the potash, and so on till the whole has passed down; if too much potash be suffered to fall at once, the extrication of gas at X will be very violent, which should be avoided. If the space between A and O should become stopped by potassium, gas will issue by the tube T (which must always be under a greater pressure of quicksilver than the tube X), and it may be fused by applying hot charcoal to the tube, when the gas will again appear at X and cease at T. When the operation is concluded, the tubes X and T are removed, and corks quickly applied to the holes; and when the apparatus is cool, the barrel is carefully removed from the furnace, and a little naphtha suffered to run through the barrel. The potassium is found in globules in the tube and receiver AA, and considerable portions often lodge at O. The success of this operation is certain, if the heat has been sufficient; but the barrel, if not very carefully covered with lute, is apt to melt, and much, if not the whole, of the product is lost. *

Potassium is a white metal of great lustre. It instantly tarnishes by exposure to air. It is ductile and of the consistency of soft wax. At 150^{0} it enters into perfect fusion; and at a bright red heat rises in vapour. At 32^{0} it is a hard and brittle solid. If heated in air it burns with a brilliant white flame.

Potassium and Oxygen.—When potassium is thrown into water it instantly takes fire,—hydrogen gas is evolved, and oxide of potassium or potash is found dissolved in the water. The quantity of hydrogen evolved in this experiment, becomes the indicator of the proportion of oxygen which has been transferred to the metal; 100 parts of potassium are thus found to absorb 20 of oxygen; and if this be considered a protoxide, then 20 : 100 :: 7,5 : 37,5,—so that 37,5 will be the number representing potassium, and 37,5 P. $+$ 7,5 O. $=$ 45 will represent

* The discovery of the nature of the alcalies, the most brilliant of modern chemistry, was made by Sir H. Davy in the year 1807, and was the result of his laborious electro-chemical researches, of which the commencement and progress are detailed in his various communications to the Royal Society.

dry oxide of potassium. Potash in the state it is usually met with in laboratories, contains a considerable portion of water, from which it may be freed by the action of iron at high temperatures, and there always remains in the barrel, after the above experiment, a large portion of dry potash. It is a hard grey substance which, by water, is slowly converted into the hydrated oxide, or caustic potash, which may be obtained by evaporation to dryness. This substance, after exposure to a red heat, is white and very soluble in water; it may be considered as a compound of 1 proportion of protoxide of potassium = 45 + 1 proportion of water = 8,5, and its number = 53,5.

Peroxide of Potassium.—If the metal be heated in considerable excess of oxygen, it burns with intense heat and light, and an orange coloured substance is obtained, which consists of 37,5 potassium + 22,5 oxygen = 60. This peroxide of potassium, when put into water, effervesces, oxygen is given off, and a solution of the hydrated protoxide is obtained.

The *hydrated protoxide*, or *caustic potash*, is procured in our laboratories by decomposing its subcarbonate by lime. It is often cast into sticks for the use of surgeons, who employ it as a caustic, and in this state it generally contains some peroxide, and therefore evolves oxygen when dissolved in water. It may be further purified by the action of alcohol, which dissolves the pure hydrate, and leaves earthy and other impurities,—the alcohol is then driven off by heat.

Hydrate of Potassa thus purified is white,—very acrid and corrosive, and at a red heat evaporates in the form of white acrid smoke. It quickly absorbs moisture from the air, and at 60° one part of water dissolves two. It may be crystallized in octoëdrons.

Chlorine and Potassium act very energetically on each other, and produce the white compound which has been called Muriate of Potash, but which is a true chloride of potassium, consisting of 37,5 P. + 33,5 Ch. It is soluble without decomposition in three parts of water at 60°. When potassium is heated in gaseous muriatic acid, this compound is formed, and hydrogen is evolved.

Chlorate of Potash is formed by passing chlorine through a solution of potash. Chloride of potassium is one of the results, the other is a salt in brilliant rhomboidal tables (formerly called Oxymuriate of Potash), the chlorate. When exposed to heat it gives out oxygen, and chloride of potassium remains. It is soluble in 18 parts of cold and 2,5 of boiling water. It acts very energetically upon many inflammables, and triturated with sulphur, phosphorus, and charcoal, produces inflammation and explosion. It consists of one proportion of chloric acid and one of potash, or 71 C. A. + 45 P. Its ultimate components, therefore, are

6 proportions of oxygen, 5 in the acid and 1 in the alcali,	= 45
1 proportion of chlorine, . . .	= 33,5
1 ———— potassium, . . .	= 37,5
	116

Iode of Potassium.—Iodine and potassium act upon each other very energetically, and a crystalline compound is obtained, white, fusible. The hydriodic acid and potash produce a similar compound.

When iodine is put into solution of potash, the results are iodate of potash and iode of potassium.

Potassium and Hydrogen.—When potassium is heated in hydrogen, it absorbs a portion of the gas, and produces a grey and highly inflammable *hydruret.* When hydrogen and potassium are passed together through a white hot tube, the gas dissolves the metal, and produces a spontaneously inflammable *potassiuretted hydrogen gas.* Both these compounds are usually formed, during the operation for obtaining potassium by the gun-barrel.

Nitrate of Potash—Nitre—Saltpetre.—This salt is an abundant natural product, and is principally brought to this country from the East Indies. It crystallizes in six-sided prisms, usually terminated by dihedral summits; it dissolves in 7 parts of water at 60°, and in its own weight at 212°. Its taste is cooling and peculiar. It consists of 1 proportion of acid = 50,5 + 1 proportion of potash = 45. Or of

6 proportions of oxygen, 5 in the acid and 1 in the alcali,	45
1 proportion of nitrogen, -	13
1 ———— potassium, -	37,5
	95,5

When exposed to a white heat, it is decomposed into oxygen, nitrogen, and potash. It fuses at a heat below redness, and congeals on cooling into cakes called *sal prunelle.* It is rapidly decomposed by charcoal at a red heat. The products of the combustion of a mixture of charcoal and nitre, are carbonic acid and nitrogen gases, and subcarbonate of potash. It is also decomposed by sulphur (see Sulphuric Acid), and by phosphorus.

This is a highly important salt, as constituting the basis of gunpowder. It is also largely employed as a source of nitric acid. (See Nitric Acid.)

Potassium unites to Sulphur with the evolution of much heat and light, and produces a red compound.

Potash and Sulphur, when fused together, form a red *sulphuret of potash.* (*Liver of Sulphur.*) Its taste is bitter and acrid. It is very soluble in water, forming a yellow solution of *hydrosulphuret of potash.* The action of the sulphuret of potash on water is complicated, and has been variously explained. By some this is considered as a compound of *potassium* and sulphur; in which case, when acted upon by water, hydrogen is imparted to the sulphur, and oxygen to the potassium; and a sulphuret of potash with excess of sulphur (or sulphuretted sulphuret of potash) is formed. If we consider the sulphuret as consisting of potash and sulphur, then the oxygen, as well as the hydrogen, of the water, must be transferred to the sulphur, and sulphuric and sulphurous acid, and sulphuretted hydrogen, would be formed; and generally when the solutions of the *livers of sulphur* are examined, sulphate and sulphite of the alcali are found. On the whole, however, it appears most probable, that when sulphur and the alcalies are fused together at a high temperature, the latter un-

dergo decomposition, and that sulphurets of their metallic bases are actually formed.

Sulphite of Potash is formed by passing sulphurous acid into a solution of potash, and evaporating out of the contact of air. Rhomboidal plates are obtained, white, of a sulphurous taste, and very soluble. By exposure to air, they pass into sulphate of potash.

Sulphate of Potash is the result of several chemical operations carried on upon a large scale in the processes of the arts. It may be formed directly by saturating sulphuric acid by potash. It crystallizes in short six-sided prisms, terminated by six sided pyramids. The body of the prism is often wanting, and the triangular faced dodecaëdron results. This salt dissolves in 16 parts of cold, and 5 of boiling water. It consists of

1 proportion of acid	=	37,5
1 ——— alcali	=	45.
		82.5

Supersulphate or Bisulphate of Potash is formed by adding sulphuric acid to a hot solution of sulphate of potash. The first crystals which form are in delicate needles of an acid taste, soluble in 2 parts of water at 60°, and consist of

2 proportions of acid	=	75.
1 ——— potash	=	45.
		120.

Phosphuret of Potassium is a brown compound, which rapidly decomposes water, producing phosphuretted hydrogen gas, and hydrophosphuret of potash.

Phosphite of Potash is a soluble deliquescent uncrystallizable salt.

Phosphate of Potash is a soluble difficultly crystallizable salt. *Superphosphate* of potash crystallizes in four-sided prisms.

Potash and Carbonic Acid.—These bodies combine in two proportions, forming the *subcarbonate* and the *bicarbonate* of potash.

Subcarbonate of Potash is a salt of great importance in many arts and manufactures, and is known in commerce in different states of purity under the names of wood ash, potash, and pearl ash.

It may be obtained directly by passing carbonic acid into a solution of potash, evaporating to dryness, and exposing the dry mass to a red heat; or by burning *tartar*, whence the name *salt of tartar* has been applied to it. This salt is fusible without decomposition, at a red heat; it is very soluble in water, and deliquesces by exposure to air, forming a dense solution, once called *oil of tartar per deliquium.* Its taste is alcaline, and it renders vegetable blues green. It consists of

1 proportion acid	=	20,7
1 ——— potash	=	45
		65,7

Bicarbonate of Potash is formed by passing a current of carbonic acid into a solution of the subcarbonate. By evaporation crystals are obtained in the form of four-sided prisms, with dihedral summits. Their taste is only slightly alcaline, and they require for solution 4 parts of water, at 60°. Exposed to a red heat, carbonic acid is evolved, and subcarbonate of potash remains. This bicarbonate consists of

2 proportions of carbonic acid	=	41,4
1 ——— potash	=	45.
		86,4

Arseniate of Potash is formed by heating together white oxide of arsenic and nitrate of potash. It crystallizes in four sided prisms.

Chromate of Potash is obtained by digesting chromate of lead in a solution of potash. The salt crystallizes in rhomboidal prisms of a yellow colour.

Sodium.

Sodium is obtained from soda by an operation analogous to that for procuring potassium from potash. In colour it resembles lead, it fuses at 180°, and is volatile at a white heat. It burns when heated in contact with air, and requires the same cautions to preserve it as potassium.

Sodium and Oxygen.—When sodium is thrown upon water, it produces violent action, but the metal does not in general inflame; hydrogen is evolved, and a solution of soda is procured. By the quantity of hydrogen evolved, we learn that soda *(protoxide of sodium)* consists of about 74,6 sodium and 25,4 oxygen *per cent.*; and, if soda be considered as the protoxide, the number representing the metal will be 22, and soda will consist of 22 S. + 7,5 O., and be represented by 29,5. By heating sodium in oxygen, an orange-coloured oxide is formed, consisting of 22 S. + 11,25 O., and which, by the action of water, evolves oxygen, and produces a solution of the protoxide.

Soda, as it usually occurs in the laboratories, is obtained from the subcarbonate by the action of lime and alcohol, as described under the head *Potash.* It consists of 29,5 oxide of sodium + 8,5 water, and is represented by 38. When soda is exposed to air, it soon becomes covered with an efflorescence of subcarbonate of soda.

Chloride of Sodium.—Sodium, when heated in chlorine, burns, and produces a white compound, of a pure saline flavour, soluble in 2½ parts of water at 60°, and forming cubic crystals. It has all the properties of *common salt,* or *muriate of soda,* and consists of

1 proportion of chlorine	=	33,5
——— sodium	=	22,
		55,5

This compound is decomposed, when heated with potassium. Sodium and chloride of potassium are the results

When soda is heated in chlorine, oxygen is evolved; when heated in muriatic acid, water is formed; and in both cases chloride of sodium is the product.

Sodium and Iodine act upon each other with the same phenomena as potassium.

Nitrate of Soda crystallizes in rhombs, soluble in three parts of water at 60°.

Sulphuret of Sodium and of Soda. (See *Potassium.*)

Sulphite of Soda is crystallizable in transparent four and six sided prisms, soluble in four parts of water at 60°.

Sulphate of Soda—Glauber's Salt—is abundantly produced in the manufacture of muriatic acid by the action of sulphuric acid upon common salt.

Common salt consists of 22 sodium + 33,5 chlorine. Sulphuric acid consists of 37.5 dry acid + 8,5 water. The water of the acid, consisting of 1 hydrogen + 7,5 oxygen, is decomposed. Its hydrogen is transferred to the chlorine to produce gaseous muriatic acid (= 1 H. + 33,5 C. = 34,5 Mur. A.), and its oxygen unites to the sodium, forming dry soda (= 7,5 Ox. + 22 S. = 29.5 soda). The 37,5 dry acid then unite to the 29.5 soda, to produce sulphate of soda, which will be represented by the number 67. Sulphate of soda crystallizes from its aqueous solution in large four-sided prisms transparent, and efflorescent, when exposed to air. They consist of 67 dry sulphate + 85 water.

Phosphate of Soda crystallizes in rhomboidal prisms, soluble in three parts of water at 60°, and efflorescing when exposed. It consists of

29,5 soda.
25 phosphoric acid.
―――
54,5

Subcarbonate of Soda is chiefly obtained by the combustion of marine plants. It consists of

29,5 soda.
20,7 carbonic acid.
―――
50,2

Its crystals contain 7 proportions of water = 59,5, which may be expelled by heat. They effloresce by exposure to air.

Bicarbonate of Soda is formed by passing carbonic acid through the solution of the subcarbonate. By evaporation, a crystalline mass is obtained. This salt consists of

29.5 soda.
41,4 carbonic acid.
―――
70,9

Barium.

To obtain this metal, the earth baryta is negatively electrized in contact with mercury; an amalgam is gradually formed, from which the mercury may be expelled by heat, and the metal barium remains, appearing, according to Sir H. Davy, of a dark grey colour, and being more than twice as heavy as water. It greedily absorbs oxygen, and burns with a deep red light when gently heated, producing the oxide of barium.

Oxide of Barium, or baryta, is obtained by exposing the nitrate of baryta to a bright red heat. It is of a grey colour, and very difficult of fusion, and appears to consist of 65 barium + 7,5 oxygen, and is consequently represented by 72,5. It eagerly absorbs water, heat is evolved, and a white solid is formed, containing about 10 *per cent.* of water; this is the *hydrate of baryta*, and may be considered as a compound of 1 proportion of baryta = 72,5 + 1 proportion of water = 8,5, and is consequently represented by 81.

This hydrate dissolves in boiling water; and, as the solution cools, deposits flattened hexagonal prisms, which contain a large quantity of water.

Baryta, like the alcalies, converts vegetable blues to green, and serves as an intermede between oil and water, whence it has been called an alcaline earth.

It exists in two natural combinations only,—namely, as sulphate and carbonate. According to M. Gay-Lussac, there is a peroxide of barium obtained by heating baryta in oxygen.

Chloride of Barium may be obtained by heating baryta in chlorine, in which case oxygen is evolved; or more easily by dissolving carbonate of baryta in diluted muriatic acid. By evaporation, tabular crystals are obtained, soluble in five parts of water at 60°; and consisting, when dry, of 65 barium + 33,5 chlorine = 98,5.

Chlorate of Baryta is formed in the same way as chlorate of potash. It crystallizes in quadrangular prisms, soluble in four parts of water, at 60°. It consists of

1 proportion of baryta	= 72,5
1 chloric acid	= 71,
	143,5

Or of 1 proportion of barium	= 65,
6 ——— of oxygen	= 45,
1 ——— of chlorine	= 33,5
	143,5.

Guy-Lussac procured chloric acid by the action of sulphuric acid upon this salt.

Iodate of Baryta is a very difficultly soluble compound—the *hydriodate* is crystallizable and very soluble.

Nitrate of Baryta crystallizes in octöedrons; it is soluble in 12 parts of cold and 4 of boiling water; it is decomposed by heat, furnishing pure baryta.

It consists of 72,5 baryta,
50,5 nitric acid.
―――
123.

Sulphuret of Barium and *Phosphuret of Barium* are brown compounds, which act upon water, as already described, producing *hydrosulphuret* and *hydrophosphuret of baryta.*

Sulphate of Baryta is an abundant natural product; it is insoluble, and therefore produced whenever sulphuric acid or a soluble sulphate is added to any soluble salt of baryta. Hence the solutions of baryta are accurate tests of the presence of sulphuric acid. They are all highly poisonous, and sulphate of soda, or dilute sulphuric acid, are the best anti-

dotes. Sulphate of barytes consists of one proportion of sulphuric acid and one of baryta.

37,5 sul. a.
72,5 baryta.

110.

Phosphate of Barytes consists of

25 phosphoric acid.
72,5 baryta.

97,5

It is insoluble in water, and therefore formed by adding a solution of phosphoric acid or phosphate of soda to nitrate or muriate of baryta.

Carbonate of Baryta is found native. Artificially produced it is a white compound insoluble in water, containing 20,7 carb. acid.
72,5 baryta.

93,2

Strontium

Is procured from the earth strontia by the same process as barium, which metal it resembles in appearance.

Oxide of Strontium, or the earth *Strontia*, is procured by the ignition of the pure nitrate; it is of a grey colour; it forms a pulverulent, and a crystallized hydrate. It consists of 44.5 strontium.
7,5 oxygen.

52

The pulverulent hydrate contains 52 strontia.
8,5 water.

60,5

Strontia and its soluble compounds are not poisonous; they tinge the flame of alcohol blood-red, while the corresponding compounds of baryta give it a yellow tint.

Chlorine and Strontium.—This compound, which has also been called Muriate of Strontia, is commonly procured by dissolving carbonate of strontia in muriatic acid. It crystallizes in slender six-sided prisms, soluble in twice their weight of water at 60°. When chlorine is made to act upon strontia, it is absorbed, and oxygen evolved. The resulting compound contains 44,5 strontium.
33,5 chlorine.

78

Nitrate of Strontia crystallizes in octoëdra; it is soluble in its weight of water at 60°. It consists of

52 strontia.
50,5 nitric acid.

102,5

Sulphate of Strontia occurs native. It is nearly insoluble, 1 part requiring 4000 of water for its solution. When heated with charcoal, its acid is decomposed, and sulphuret of strontia is formed, which affords nitrate by the action of nitric acid. This process, equally practicable upon sulphate of baryta, is sometimes adopted to obtain the earth. Sulphate of strontia contains 52 strontia.
37,5 acid.

89,5

Phosphate of Strontia is an insoluble white salt, containing 52 strontia.
25 acid.

77

Carbonate of Strontia exists native. Artificially formed, it is a white insoluble body, containing

52 strontia.
20,7 carbonic acid.

72,7

Calcium.

When lime is electrized negatively in contact with mercury, an amalgam is obtained, which, by distillation, affords a white metal. It has been called *calcium*, and, when exposed to air, and gently heated, it burns, and produces the *oxide of calcium*, or lime.

Lime appears to consist of 19 parts of this metallic base united to 7,5 parts of oxygen, so that its representative number will be = 26,5. The combinations of lime are very abundant natural products, and of these the native carbonate, which, more or less pure, constitutes the different kinds of marble, chalk, and limestone, and which is also the leading hardening principle of shell, coral, &c. may be considered as the most important.

Pure lime may be obtained by exposing powdered white marble to a white heat. Its colour is grey, it is acrid and caustic, and converts vegetable blues to green; its specific gravity is 2,3, it is very difficult of fusion. Exposed to air it becomes white by the absorption of water and a little carbonic acid. When thrown into water, a considerable rise of temperature ensues. At the temperature of 60°, 750 parts of water are required for the solution of one part of lime.

Chloride of Calcium is produced by heating lime in chlorine, in which case oxygen is evolved; or by evaporating muriate of lime to dryness, and exposing the dry mass to a red heat in close vessels. It consists of 19 calcium + 33,5 chlorine = 52,5. This compound has a strong attraction for water, it deliquesces when exposed to air, and is difficultly crystallizable from its aqueous solutions.

Iodate of Lime is difficultly crystallizable in small quadrangular prisms.

Hydriodate of Lime is very deliquescent; when dried, it becomes *Iode of Calcium*, a white fusible compound.

Nitrate of Lime is a deliquescent salt soluble in 4 parts of water at 60°. It is found in old plaster and mortar, from the washings of which nitre is pro-

cured by the addition of subcarbonate of potash. It is composed of

Lime,	26,5
Nitric acid,	50,5
	77

Sulphuret of Lime is formed by heating lime with sulphur. It is soluble in water with the same phenomena as sulphuret of potash.

Sulphate of Lime occurs native in selenite, gypsum, and plaster stone. It is easily formed artificially, and then affords silky crystals soluble in 350 parts of water. When these or the native crystallized sulphate are exposed to a red heat, they lose water, and fall into a white powder (plaster of Paris), which, made into a paste with water, soon solidifies. Dry sulphate of lime consists of

26,5	lime,
37,5	sulp. acid.
64	

Crystalline selenite contains two proportions of water, and is consequently represented by 64 + 17, or 81. As sulphate of lime is more soluble in water than pure lime, sulphuric acid affords no precipitate when added to lime-water. Nearly all spring and river water contains this salt, and in those waters which are called *hard* it is abundant.

Phosphuret of Lime.—By passing phosphorus over red-hot lime, a brown compound is produced, which rapidly decomposes water with the evolution of phosphuretted hydrogen gas. Hydrophosphuret and phosphate of lime are also formed.

Phosphate of Lime exists abundantly in the bones of animals; it is also found in the mineral world. It may be formed artificially, by mixing solutions of phosphate of soda and of lime. It is insipid and insoluble, but dissolves in dilute nitric and muriatic acid without decomposition. It is decomposed by sulphuric acid, and thus the phosphoric acid for the production of phosphorus is usually procured. It consists of

26,5	lime,
25	phosphoric acid.
51,5	

Superphosphate of Lime may be obtained by dissolving the phosphate in phosphoric acid; by evaporation, it affords small crystalline laminæ.

Carbonate of Lime is the most abundant compound of this earth. When lime-water is exposed to air, it becomes covered with an insoluble film of carbonate of lime, and hence is an excellent test of the presence of carbonic acid. But excess of carbonic acid redissolves the precipitate, producing a supercarbonate. Carbonate of lime is precipitated by the carbonated alcalies from solutions of muriate and nitrate of lime. Exposed to a red heat the carbonic acid escapes, and *quicklime* is obtained.

It consists of

26,5	lime,
20,7	carbonic acid.
47,2	

Fluor Spar—Fluate of Lime.—These terms have been applied to a body containing a peculiar principle which has not hitherto been obtained in an insulated state.

It is a principle which probably belongs to the acidifying supporters of combustion, and which in fluor spar is perhaps united to calcium. It appears to be united with hydrogen in the *fluoric*, or *hydrofluoric* acid. This supposed base has been called *fluorine* by Sir H. Davy; and *phtore* (from φθόριος, *destructive*), by M. Ampére.

Hydrofluoric acid (hydrophtoric) is procured by distilling a mixture of one part of the purest fluor spar in fine powder with two of sulphuric acid; the distillatory apparatus and receiver should be of lead or silver; the heat required is not considerable; sulphate of lime remains in the retort; and a highly acrid and corrosive liquid passes over, which requires the assistance of ice for its condensation. This acid is colourless, of a very pungent smell, and extremely destructive. If applied to the skin, it instantly kills the part, produces extreme pain, and extensive ulceration. At 80° it becomes gaseous; it has never been frozen; it produces white fumes when exposed to a moist air. This acid acts upon potassium and sodium, and some other metals, with great energy; hydrogen is evolved, and a peculiar compound, probably of the basis of the acid and of the metal, results. These compounds might be called *fluorides*.

Fluoboric Acid.—This is probably a compound of fluorine with boron. It is gaseous, and may be obtained by heating in a glass retort twelve parts of sulphuric acid with a mixture of one part of fused boracic acid, and two of fluate of lime reduced to a very fine powder. The gas must be received over mercury: 100 cubical inches weigh 73,5 grains; so that the specific gravity of fluoboric acid, compared with hydrogen, is 32,68; and, with atmospheric air, 2,371. It produces very copious fumes when suffered to escape into a moist atmosphere; and, when acted upon by water which dissolves 700 times its volume, it affords a solution of hydrofluoric and boracic acids, whence it would seem that the hydrogen is transferred to the fluorine, and the oxygen to the boron. It acts with great energy on vegetable and animal bodies, depriving them of moisture and hydrogen.

Magnium.

The metallic base of magnesia has not hitherto been obtained; but, when that earth is negatively electrized with mercury, the resulting compound decomposes water, and gives rise to the formation of *magnesia*.

Magnesia, or Oxide of Magnium—is concluded, from indirect experiments, to consist of 11 metal + 7,5 oxygen; its representative number, therefore, is 18,5. Magnesia is a white insipid substance, which slightly greens the blue of violets. Its specific gravity is 2,3; it is almost infusible and insoluble in water.

Chloride of Magnium may be obtained by passing chlorine over red-hot magnesia; oxygen is expelled, and a substance obtained which moisture converts into muriate of magnesia.

Muriate of Magnesia is very deliquescent, and difficultly crystallized. Its solution has a bitter saline taste. Exposed to heat, muriatic acid flies off, and the magnesia remains pure. In consists of

Magnesia,	18,5
Muriatic acid,	34,5
	53

Chlorite of Magnesia is a bitter deliquescent salt.

Hydriodate of Magnesia is deliquescent, and loses hydriodic acid by exposure to heat.

Nitrate of Magnesia crystallizes in rhomboidal prisms, deliquescent and soluble in half its weight of water. It contains

Magnesia,	18,5
Nitric acid,	50,5
	69

Sulphate of Magnesia is a commonly occurring compound of this earth, much used in medicine as an aperient. It is largely consumed in the preparation of carbonate of magnesia. It crystallizes in four-sided prisms with reversed dihedral summits, or four-sided pyramids. Its taste is bitter. It is soluble in its own weight of water at 60^0. When exposed to a red heat, it loses its water of crystallization, amounting to about 50 *per cent.*, but is not decomposed. It consists of

Magnesia,	18,5
Sulphuric acid,	37,5
	56

In its crystallized state, it may be considered as composed of 1 proportion of dry sulphate + 7 proportions of water,

Or, 56	Sulphate,
59,5	Water.
115,5	

This salt is usually obtained from sea-water, occasionally from saline springs, and sometimes by the action of sulphuric acid on magnesian limestones.

Carbonate of Magnesia is generally procured by adding carbonated alcalies to a solution of sulphate of magnesia. It is a white, insipid, and insoluble powder, which loses its acid at a red heat, and thus affords pure (calcined) magnesia. It contains

18,5	Magnesia,
20,7	Carbonic acid.
39,2	

It is soluble in excess of carbonic acid, and this solution affords crystals of bicarbonate, containing

18,5	Magnesia,
41,4	Carbonic acid.
59,9	

Silicium.

It has been assumed that the earth silica consists of a metallic basis, united with oxygen, and that it contains 50 *per cent.* of each of its components; so that, if the earth be considered a deutoxide, it will consist of

15	Silicium,
15	Oxygen.
30	

Oxide of Silicium, Silica, or Siliceous Earth—is a very abundant natural product. It exists pure in rock-crystal, and nearly pure in flint. Its colour is white; its specific gravity 2,66. It fuses at a very high temperature. In its ordinary state it is insoluble in water; but it dissolves in very minute portions in that fluid, when recently precipitated in the form of hydrate; and in the same state it dissolves in the acids. It readily unites with the fixed alcalies, and forms *glass;* or, if the alcali be in excess, a liquid solution of the earth may be obtained, whence it is precipitated in the state of a gelatinous hydrate by acids.

The only body which acts energetically upon silica is the hydrofluoric acid. The result of this action is a gaseous compound, which has been called *silicated fluoric acid;* it is probably a compound of silicium and fluorine. To obtain this gas, three parts of fluor spar, and one of silica finely powdered, are mixed in a retort with an equal weight of sulphuric acid; a gentle heat is applied, and the gas evolved is to be collected over mercury.

Silicated fluoric acid is a colourless gas; its odour is acrid, much resembling muriatic acid; its taste very sour; its specific gravity 3,574 to air; 100 cubic inches = 110,78 grains, so that its specific gravity to hydrogen is 4,92. It extinguishes burning bodies. It produces white fumes when in contact with damp air, and when exposed to water, a little hydrogen is evolved, and two compounds of silica with fluoric acid are formed; the one *acid*, and dissolved in the water, the other containing excess of earth, and insoluble. The dry gas contains 62 *per cent.* of silica; the aqueous solution only retains 55 *per cent.* Water dissolves 260 times its bulk of this gas. When one volume of silicated fluoric acid is mixed with two of ammonia, a total condensation ensues, and a dry *silica fluate of ammonia* results. Potassium, when heated in this gas, burns and produces a brown compound, which, when dissolved in water, affords *fluate of potash*. The uses of silica are numerous and important; it forms an ingredient in pottery and porcelain, and with alcali it forms glass. It appears from the experiments of Mr J. F. Daniell, that silicium exists in some of the varieties of cast iron. (*Journal of Science and Arts*, Vol. II.)

Alumium.

The earth alumina constitutes some of the hardest gems, such as the sapphire and ruby, and it gives a peculiar softness and plasticity to some earthy compounds, such as the different kinds of clay. It is analogically considered as a metallic oxide.

To obtain pure alumina we add carbonate of potash to a solution of alum, and ignite the precipitate; it is a tasteless white substance, forming a cohesive mass with water, and retaining water even at a red heat; its specific gravity is 2; it is soluble in soda and potash; and forms compounds with baryta, strontia, lime, and silica. It is an essential ingredient in pottery and porcelain.

One of its saline combinations is of important use in the arts, namely alum; a triple sulphate of alumina and potash. This salt is usually prepared by roasting and lixiviating certain clays containing pyrites; to the lyes, a certain quantity of potash is added, and the triple salt is obtained by crystallization.

Alum has a sweetish astringent taste. It dissolves in five parts of water at 60^0, and the solution reddens blues. It furnishes octoëdral crystals. When heated, it loses water of crystallization, and a part of its acid, and becomes a white spongy mass. In its crystalline form, it consists of

Sulphuric acid, -	33
Alumina, - -	12
Potash, - -	9
Water, - -	46
	100

When alum is ignited with charcoal, a spontaneously inflammable compound results, which has long been known under the name of Homberg's pyrophorus. The potash is decomposed in this process, along with the acid of the alum, and pyrophorus is a compound of sulphur, charcoal, and potassium, with alumina.

Zirconium.

The earth *zircon*, or the *oxide of zirconium*, is a white insipid substance; specific gravity 4,3; it is found in the zircon of Ceylon; it is characterized by insolubility in pure alcalies, but is soluble in alcaline carbonates. Its combinations with the acids are of difficult solubility or insoluble, and have been very little inquired into.

Yttrium.

The earth *yttria* derives its name from Yttertz in Sweden; it is found in the mineral called *gadolinite*. It is white and tasteless; its specific gravity = 4,84. It is insoluble in the caustic alcalies, but dissolves sparingly in carbonate of ammonia. Its saline combinations have been scarcely examined.

Glucium.

The earth *glucine* was discovered by Vauquelin in the beryl; it also exists in the emerald of Peru; it is white and insipid; its specific gravity = 2,97. It dissolves in caustic potash, and soda, and thus resembles alumine, but differs from yttria. Again, it differs from alumine, but resembles yttria in being soluble in carbonate of ammonia; it is much more soluble in this solution than yttria. With the acids it forms saline compounds of a sweetish astringent taste.

TABLE

Exhibiting the Specific Gravities and Representative Numbers of the Metals, and of their Combinations; with the General and Distinctive Characters of the Metallic Salts.

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Metals of First Class.				The salts of gold are yellow and soluble in water. Potash and soda produce in them yellow precipitates. Sulphuretted hydrogen and hydrosulphuret of ammonia occasion black precipitates, phosphuretted hydrogen, a purple precipitate, a plate of tin or muriate of tin, a purple powder. Sulphate of iron separates minutely divided metallic gold. Tincture of galls gives a brown precipitate. Triple prussiate of potash occasions no precipitate.
Gold	19,30	97		
—— peroxide . .		104,5	97 G. + 7,5 ox.	
—— chloride . .		130,5	97 G. + 33,5 C.	
—— muriate . .		139	104,5 ox. G. + 34,5 M. A.	
—— chlorate .				
—— iode . . . —— hydriodate . .	Hydriodic acid produces an insoluble yellow precipitate in dilute muriate of gold, which is the iode of gold. Heat separates the iodine.			
—— nitrate . .		155	104,5 ox. G. + 50,5 N. A.	
—— sulphuret . .		127	97 G. + 30 S.	
—— sulphite . .	Sulph. acid produces a metallic precipitate in solution of gold.			
—— sulphate . .				
—— hydrosulphuret .				
—— phosphuret .		117	97 G. + 20 P.	
—— phosphite . . —— phosphate . .	Neither these acids, nor their neutral salts, occasion any precipitate in solution of muriate of gold.			

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Gold hydrophosphuret .				
—— carbonate . .				
—— cyanuret . .				
—— prussiate . .				
—— borate . .				
Silver . . .	10,50	102		The salts of silver are reduced upon charcoal by the blowpipe. The soluble salts are precipitated by the alcalies, which furnish dark olive precipitates; by sulphuretted hydrogen and hydrosulphuret of ammonia, nearly black; by infusion of galls, yellow brown; by prussiate of potash and iron, white. Muriatic acid and the muriates give white precipitates of chloride of silver. Sulphate of iron, and a plate of copper, throw down metallic silver.
—— oxide . . .		109,5	102 S. + 7,5 ox.	
—— chloride . .		135,5	102 S. + 33,5 C.	
—— muriate . .				
—— chlorate . .			A detonating salt.	
—— iode . . .			Hydriodic acid throws down iode of silver from the nitrate, at first white, but becoming *very* soon yellow, then grey and blackish.	
—— hydriodate .				
—— nitrate . .		160	109,5 O. S. + 50,5 N. A.	
—— ammoniuret .			Liquid ammonia easily dissolves the oxide of silver. When the solution is evaporated, a grey compound remains, which leaves metallic silver when heated. Sometimes it detonates.	
—— sulphuret . .		117	102 S. + 15 Sul.	
—— sulphite . .			forms a white and difficultly soluble salt.	
—— sulphate . .		147	109,5 O. S. + 37,5 S. A.	
—— hydrosulphuret .				
—— phosphuret .				
—— phosphate .		134,5	109.5 O. S. + 25 P. A.	
—— carbonate .		130,2	109,5 O. S. + 20,7 C. A.	
—— cyanuret . .				
—— hydrocyanate .		134,9	109,5 O. S. + 25,4 Hc. A.	
—— borate . .			Boracic acid produces no precipitate in solutions of silver, but borate of soda throws down a white *borate of silver*.	
Platinum . .	21	92		The solutions of these salts are deep or brownish yellow. They afford no precipitate with solutions of soda, of sulphate of iron, or of prussiate of potash. The addition of the latter produces a fine green solution. Potash and ammonia, and many of their salts, occasion yellow precipitates. Sulphuretted hydrogen occasions a black precipitate. Infusion of galls gives a dingy precipitate.
—— protoxide .		99,5	92 P. + 7,5 O.	
—— peroxide .				
—— chloride .		125,5	92 P. + 33,5 C.	
—— muriate .		134	99,5 O. P. + 34,5 M. A.	
—— iode .			Hydriodic acid precipitates a dingy brown iode of platinum, decomposed by heat.	
—— hydriodate .				
—— nitrate .				
—— ammoniuret .				
—— ammonia muriate				
—— sulphuret .		107	92 P. + 15 S.	
—— sulphate .				
—— hydrosulphuret			Hydrosulphuret of ammonia produces a brown precipitate in muriate of platinum. This is probably a sulphuretted hydrosulphuret.	
—— phosphuret .				
—— phosphate .			A soluble salt, obtained by dissolving oxide of platinum in phosphoric acid.	
—— prussiate .				
Palladium . .	11,50			The Salts of Palladium are precipitated by sulphate of iron; also brown by sulphuretted hydrogen; black by muriate of tin; greenish brown by prussiate of potash; deep orange by sulphate and nitrate of potash.
—— oxide . .			Contains, according to Vauquelin, 20 *per cent* oxygen.	
Rhodium . .				The Salts of Rhodium are not

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Rhodium oxide				precipitated by muriate of ammonia, hydrosulphuret of ammonia, prussiate of potash, or alcaline carbonates. The caustic alcalies occasion a yellow precipitate. The salts of iridium are soluble in water, and generally of a blue colour.
Iridium				
—— oxide				
Metals of Second Class.				
Osmium				
—— oxide				
Mercury	13,50	190		The Mercurial Salts are volatilized by heat. They are precipitated yellowish by prussiate of potash; deep brown by hydrosulphuret of ammonia; and copper separates pure mercury. The salts, with the protoxide, furnish black precipitates with the alcalies, and white with muriatic acid. The salts with the peroxide furnish to the fixed alcalies reddish precipitates, and white with ammonia.
—— protoxide		197,5	190 M. + 7,5 O.	
—— peroxide		205	190 M. + 15 O.	
—— chloride		223,5	190 M. + 33,5 C.	
—— bichloride		257	190 M. + 67 C.	
—— muriate				
—— chlorate	Chlorate of Mercury is yellow and insoluble. Oxychlorate furnishes crystals.			
—— iode				
—— hydriodate				
—— nitrate		248	197,5 O. M. + 50,5 N. A.	
—— sulphuret		205	190 M. + 15 S.	
—— bisulphuret		220	190 M. + 30 S.	
—— sulphite				
—— sulphate		235	197,5 O. M. + 37,5 S. A.	Hydriodic Acid furnishes a yellow precipitate in solutions of protoxide, and a red precipitate with the peroxide. These are the protiode and periode of mercury.
—— oxysulphate				
—— superoxysulphate				
—— suboxysulphate				
—— hydrosulphuret				
—— phosphuret				
—— phosphate				Phosphoric Acid produces a white insoluble precipitate in nitrate of mercury, but no precipitate in the oxynitrate.
—— oxyphosphate		255	205 O. M. + 50 P. A.	
—— carbonate		218,2	197,5 O. M. + 20,7 C. A.	
—— cyanuret		238,8	190 M. 48,8 C.	
—— prussiate				
Lead	11,35	97		The soluble Salts of Lead furnish colourless solutions of a sweetish taste, precipitated white by sulphate and prussiate of potash, and by infusion of galls; and brownish black by sulphuretted hydrogen and hydrosulphuret of ammonia. Hydriodic acid affords a fine yellow precipitate of iode of lead. The alcalies produce white precipitates, *easily soluble* in excess of potash or soda, but *insoluble* in excess of ammonia. Zinc precipitates metallic lead. The insoluble salts of lead treated by the blow-pipe or charcoal, afford a globule of lead.
—— 1. oxide		104,5	97 L. + 7,5 O.	
—— 2. oxide		108,25	97 L. + 11,25 O.	
—— 3. oxide		112	97 L. + 15 O.	
—— chloride		130,5	97 L. + 33,5 C.	
—— chlorate	A soluble salt, crystallizing in brilliant laminæ.			
—— iode				
—— nitrate		155	104,5 O. L. + 50,5 N. A.	
—— sulphuret		112	97 L. + 15 S.	
—— sulphate		142	104,5 O. L. + 37,5 S. A.	
—— hydrosulphuret				
—— phosphuret				
—— phosphate		129,5	104,5 O. L. + 25 P. A.	
—— carbonate		125,2	104,5 O. L. + 20,7 C. A.	
—— prussiate				
Nickel	8,25	55,5		The Salts of Nickel furnish green solutions, of a sweetish acrid flavour; ammonia furnishes green precipitates, redissoluble in excess of alcali, and forming triple salts. Prussiate of potash forms a greenish precipitate; hydrosulphuret of ammonia gives a black
—— oxide		70,5	55,5 N. + 15 O.	
—— hydrate				
—— chloride		122,5	55,5 N. + 67 C.	
—— muriate		139,5	70,5 O. N. + 69 M. A.	
—— nitrate				
—— ammoniuret				
—— sulphuret		85,5	55 5 N. + 30 S.	
—— supersulphuret		100,5	55,5 N. + 45 S.	

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Nickel sulphate		108	70,5 O. N. + 37,5 S. A.	precipitate; hydriodic acid forms a pea-green iode.
——— phosphuret		75,5	55,5 N. + 20 P.	
——— phosphate		95,5	70,5 O. N. + 25 P. A.	
——— carbonate		91,2	70,5 O. N. + 20,7 C. A.	
——— prussiate				
Metals of Third Class.				
Arsenic	8,35	45		Hydriodic Acid produces a precipitate of white oxide of arsenic, when added to arsenite of potash, and hydriodate of potash is formed. Arsenite of potash gives a white precipitate, with hydrosulphuret of ammonia; a white precipitate soon becoming yellow and brown with nitrate of silver; a grey precipitate with nitrate, and a white with oxynitrate of mercury; a white with nitrate of lead; a pale green with nitrate of nickel; pale pink by nitrate of cobalt; apple green with nitrate of copper; white with the muriate and oxymuriate of tin; dingy green with the muriate and oxymuriate of iron; white with sulphate of zinc; bright yellow with nitrate of uranium.
——— 1. oxide		60	45 A. + 15 O.	
——— 2. oxide		67,5	45 A. + 22,5 O.	
——— chloride		112	45 A. + 67 C.	
——— muriate				
——— iode				
——— hydruret				
——— arsenic hydrogen				
——— sulphuret		60	45 A. + 15 S.	
——— bisulphuret		75	45 A. + 30 S.	
——— sulphate				
Arseniate of ammonia				
——— silver				
——— mercury				
——— lead				
——— nickel				
Molybdenum	7,40	44		
——— 1. oxide		51,5	44 M. + 7,5 O.	
——— 2. oxide		59	44 M. + 15 O.	
——— 3. oxide		66,5	44 M. + 22,5 O.	
——— sulphuret		74	44 M. + 30 S.	The Arseniate of Potash produces a reddish precipitate in nitrate of silver; straw-coloured with nitrate, and yellow with oxynitrate of mercury; white with nitrate of lead; pale green with nitrate of nickel; pale blue with nitrate of copper; pink with nitrate of cobalt; white with muriate of tin; no precipitate with oxymuriate of tin; pale sea-green with muriate and oxymuriate of iron; straw colour with nitrate of uranium; and white with sulphate of zinc. The compounds of the arsenic and arsenious acids are decomposed when heated with charcoal, and exhale an alliaceous smell.
Chrome				Chromic Acid and Chromate of Soda produce insoluble precipitates in solutions of silver, mercury, lead, copper, iron, and uranium; the colours are crimson, red, yellow or orange, apple green, brown, and yellow. No precipitate is formed in solutions of nickel, zinc, tin, cobalt, gold, or platinum.
——— 1. oxide				
——— 2. oxide				
Tungsten				
——— 1. oxide				
——— 2. oxide				
Columbium				

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Antimony . . .	6,70	85		The soluble binary salts of the protoxide of antimony are precipitated white by water; the precipitate is a subsalt. Sulphuretted hydrogen, and hydrosulphuret of ammonia, give an orange precipitate, and a plate of iron or zinc throws down the metal in the form of a black powder.
—— 1. oxide .		100	85 A. + 15 O.	
—— 2. oxide .		107,5	85 A. + 22,5 O.	
—— chloride .		152	85 A. + 67 C.	
—— muriate .				
—— iode . .				
—— sulphuret .		115	85 A. + 30 S.	
—— sulphate .				
—— hydrosulphuret				
—— phosphuret				
—— phosphate				
Uranium . . .	9			Of the Salts of Uranium the greater number are soluble, and of a greenish yellow colour; they form yellow precipitates with the alcalies, and afford a reddish yellow iode with hydriodic acid. Prussiate of potash forms a precipitate of a rich brown colour, and hydrosulphuret of ammonia one nearly black.
—— oxide . .				
Cerium . . .		86		
—— 1. oxide . .		101	86 C. + 15 O.	
—— 2. oxide . .		108,5	86 C. + 22,5 O.	
Cobalt	8			Nearly all the Salts of Cobalt are of a red colour; potash, soda, and ammonia, produce in them blue precipitates of hydrated oxide, which is soluble in excess of ammonia, producing a red solution. Hydrosulphuret of ammonia gives a black precipitate. Prussiate of potash a pale green. Carbonates, phosphates, and arseniates, produce red precipitates. Hydriodic acid does not precipitate the salts of cobalt.
—— 1. oxide . .				
—— 2. oxide . .				
—— chloride . .				
—— muriate . .				
—— sulphuret . .				
—— sulphate . .				
—— hydrosulphuret .				
—— phosphuret . .				
—— phosphate . .				
Titanium . .		135		The Salts of Titanium are colourless, and afford white precipitates with the alcalies. Prussiate of potash gives a green precipitate, and infusion of galls a red one. Hydrosulphuret of ammonia gives a green precipitate.
—— 1. oxide .		142,5	135 T. + 7,5 O.	
—— 2. oxide .				
—— 3. oxide .		150	135 T. + 15 O.	
Bismuth . .	9,80	66,5		The Salts of Bismuth are precipitated white by water—brownish black by sulphuretted hydrogen—yellowish white by precipitate of potash, and hydriodic acid affords a deep brown iode of bismuth.
—— oxide . .		74	66,5 B. + 7,5 O.	
—— chloride .		100	66,5 B. + 33,5 C.	
—— nitrate . .		124,5	74 O. B. + 50,5 N. A.	
—— sulphuret .		81,5	66,5 B. + 15 S.	
—— sulphate .				
—— hydrosulphuret				
Copper . . .	8,90	60		The salts of this metal are distinguished by their blue and green colours; their solutions afford blue precipitates of hydrated oxide with the alcalies, and these redissolve in excess of ammonia, producing a deep blue solution. A plate of iron precipitates metallic copper; prussiate of potash affords a
—— 1. oxide . .		67,5	60 C. + 7,5 O.	
—— 2. oxide . .		75	60 C. + 15 O.	
—— 1. chloride .		93,5	60 C. + 33,5 C.	
—— 2. chloride .		127	60 C. + 67 C.	
—— submuriate .		184,5	150 O. C. + 34,5 M. A.	
—— muriate . .		144	75 O. C. + 69 M. A.	
—— chlorate . .				
—— nitrate . .		125,5	75 O. C. + 50,5 N. A.	
—— ammoniuret .				

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Copper sulphuret		75	60 C. + 15 S.	fine brown precipitate ; hydrosulphuret of ammonia one of a dirty brown ; hydriodic acid produces an insoluble iode of an ash grey colour.
—— bisulphuret		90	60 C. + 30 S.	
—— sulphite				
—— sulphate (dry)			75 O. C. + 75 S. A.	
—— hydrosulphuret				
—— phosphuret				
—— phosphate		92,5	67,5 O. C. + 25 P. A.	
—— oxyphosphate		125	75 O. C. + 50 P. A.	
—— carbonate		95,7	75 O. C. + 20,7 C. A.	
—— prussiate				
Tellurium	6,10	37		
—— oxide		44,5	37 T. + 7,5 O.	
—— chloride		70,5	37 T. + 33,5 C.	
Metals of Fourth Class.				
Iron	7,78	52		The Solutions of Iron are known by affording a purple or black precipitate to infusion of galls. They give no precipitate with hydriodic acid.
—— 1. oxide		67	52 I. + 15 O.	
—— 2. oxide		74,5	52 I. + 22,5 O.	
—— 1. chloride		119	52 I. + 67 C.	
—— 2. chloride		152,5	52 I. + 100,5 C.	
—— muriate		136	67 O. I. + 69 M. A.	
—— oxymuriate		178	74,5 O. I. + 103,5 M. A.	
—— chlorate				
—— iode				
—— nitrate		168	67 O. I. + 101 N. A.	
—— oxynitrate		226	74,5 O. I. + 151,5 N. A.	
—— sulphuret		82	52 I. + 30 S.	
—— bisulphuret		112	52 I. + 60 S.	
—— sulphate		142	67 O. I. + 75 S. A.	
—— —— crystallized				
—— oxysulphate		187	74,5 O. I. + 112,5 S. A.	
—— hydrosulphuret				
—— phosphuret				
—— phosphate		117	67 O. I. + 50 P. A.	
—— oxyphosphate				
—— carburet				
—— carbonate		108,4	67 O. I. + 41,4 C. A.	
—— prussiate				
Tin	7,30	55		The Hydriodic Acid affords a fine orange precipitate with solution of muriates of tin, provided there be no excess of acid. Hydrosulphuret of ammonia produces a precipitate of a deep orange colour. The other characters are noticed in the text.
—— 1. oxide		62,5	55 T. + 7,5 O.	
—— 2. oxide		70	55 T. + 15 O.	
—— 1. chloride		88,5	55 T. + 33,5 O.	
—— 2. chloride		122	55 T. + 67 C.	
—— muriate		97	62,5 O. T. + 34,5 M. A.	
—— oxymuriate		139	70 O. T. + 69 M. A.	
—— iode				
—— nitrate		113	62,5 O. T. + 50,5 N. A.	
—— sulphuret		70	55 T. + 15 S.	
—— bisulphuret		85	55 T. + 30 S.	
—— sulphate				
—— hydrosulphuret				
—— phosphuret		65	55 T. + 10 P.	
—— prussiate				
Zinc	7	33		The Solutions of Zinc are not precipitated by hydriodic acid. Potash, soda, and ammonia, form white precipitates redissoluble in excess either of acid or alcali. Hydrosulphuret of ammonia produces a
—— oxide		40,5	33 Z. + 7,5 O.	
—— chloride		66,5	33 Z. + 33,5 C.	
—— muriate		75	40,5 O. Z. + 34,5 M. A.	
—— iode				
—— hydriodate				
—— nitrate		91	40,5 O. Z. + 50,5 N. A.	

Chemistry.

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Zinc sulphuret		48	33 Z. + 15 S.	yellowish white precipitate, and the soluble phosphates, borates, and carbonates, all form white precipitates.
—— sulphate		78	40,5 O. Z. + 37,5 S. A.	
—— hydrosulphuret				
—— phosphuret				
—— phosphate		65,5	40,5 O. Z. + 25 P. A.	
—— carbonate		61,2	40,5 O. Z. + 20,7 C. A.	
—— prussiate				
Manganese	6,85	56,5		The Salts of Manganese are not precipitated by hydriodic acid. They furnish white precipitates with the alcalies, which blacken by exposure to air. They are precipitated white by prussiate of potash, and yellow by hydrosulphuret of ammonia.
—— 1. oxide		71,5	56,5 M. + 15 O.	
—— —— hydrate		88,5	71,5 O. M. + 17 W.	
—— 2. oxide		79	56,5 M. + 22,5 O.	
—— chloride		123,5	56,5 M. + 67 C.	
—— muriate		140,5	71,5 O. M. + 69 M. A.	
—— nitrate				
—— sulphuret				
—— sulphate		146,5	71,5 O. M. + 75 S. A.	
—— phosphuret				
—— phosphate				
—— carbonate		112,9	71.5 O. M. + 41,4 C. A.	
—— prussiate				
Metals of Fifth Class.				
Potassium	0,85	37,5		The following characters belong to the Salts of Potassium: They are all soluble in water, and afford no precipitates with pure or carbonated alcalies; they produce a precipitate in muriate of platinum, which is a triple compound of potassa, oxide of platinum, and muriatic acid. They are not changed by sulphuretted hydrogen, nor by prussiate of potash. Added to sulphate of alumine, they enable it to crystallize so as to form alum.
—— protoxide		45	37,5 P. + 7,5 O.	
—— —— hydrate		53,5	45 O. P. + 8,5 water.	
—— peroxide		60	37,5 P. + 22,5 O.	
—— chloride		71	37,5 P. + 33,5 C.	
—— chlorate		116	45 O. P. + 71 C. A.	
—— iode		155,25	37,5 P. + 117,75 I.	
—— hydriodate		163,75	45 O. P. + 118,75 H. A.	
—— oxiodate				
—— hydruret				
—— hyd. potassuretted				
—— nitrate		95,5	45 O. P. + 50,5 N. A.	
—— sulphuret		52,5	37,5 P. + 15 S.	
—— sulphite		75	45 O. P. + 30 S. A.	
—— sulphate		82,5	45 P. + 37,5 S. A.	
—— bisulphate		120	45 O. P. + 75 S. A.	
—— phosphuret				
—— phosphite		62,5	45 O. P. + 17,5 P. A.	
—— phosphate		70	45 O. P. + 25 P. A.	
—— carbonate		65,7	45 O. P. + 20,7 C. A.	
—— bicarbonate		86,4	45 O. P. + 41,4 C. A.	
—— cyanuret				
—— prussiate				
—— arsenite				
—— arseniate				
—— chromate				
Sodium	0,9	22		All the Salts of Soda are soluble in water; they are not precipitated by pure or carbonated alcalies, nor by hydrosulphuret of ammonia, nor prussiate of potash; nor do they produce any precipitate in solution of muriate of platinum. They do not convert sulphate of alumine into alum.
—— 1. oxide		29,5	22 S. + 7,5 O.	
—— —— hydrated		38	29,5 O. S. + 8,5 W.	
—— peroxide				
—— chloride		55,5	22 S. + 33,5 C.	
—— chlorate		100,5	29,5 O. S. + 71 C. A.	
—— iode		139,75	22 S. + 117,75 I.	
—— oxiodate		184,75	29.5 O. S. + 155.25 O. A.	
—— hydriodate		148,25	29,5 O. S. + 118,75 H. A.	
—— nitrate		80	29,5 O. S. + 50,5 N. A.	
—— sulphuret				
—— sulphite				

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Sodium sulphate		67	29,5 O. S + 37,5 S. A.	
—— phosphuret				
—— phosphite		47	29,5 O. S. + 17,5 P. A.	
—— phosphate		54,5	29,5 O. S. + 25 P. A.	
—— biphosphate		79,5	29,5 O. S. + 50 P. A.	
—— subcarbonate		50,2	29,5 O. S. + 20,7 C. A.	
—— bicarbonate		70,9	29,5 O. S. + 41,4 C. A.	
—— cyanuret				
—— prussiate				
—— subborate				
—— arseniate				
Barium		65		The Soluble Barytic Salts furnish white precipitates of carbonate of baryta, by the alcaline subcarbonates. Sulphuric acid and the soluble sulphates occasion white precipitates of sulphate of baryta in the solution of the earth. They are poisonous, and tinge flame yellow.
—— oxide		72,5	65 B. + 7,5 O.	
—— —— hydrate		81	72,5 O. B. + 8,5 W.	
—— chloride		98,5	65 B. + 33,5 C.	
—— chlorate		143,5	72,5 O. B. + 71 C. A.	
—— iode				
—— oxiodate				
—— hyriodate				
—— nitrate		123	72,5 O. B. + 50,5 N. A.	
—— sulphuret				
—— sulphite		102,5	72,5 O. B. + 30 S^s. A.	
—— sulphate		110	72,5 O. B. + 37,5 S. A.	
—— phosphuret				
—— phosphite				
—— phosphate		97,5	72,5 O. B. + 25 P. A.	
—— carbonate		93,2	72,5 O. B. + 20,7 C. A.	
Strontium		44,5		The Salts of Strontium furnish white precipitates with the alcaline subcarbonates, and with sulphuric acid and sulphates; they tinge flame of a fine red; they are not poisonous. They are decomposed by baryta, which has a stronger attraction for acids than strontia; they are more soluble than barytic salts, but pure strontia is less soluble than baryta.
—— oxide		52	44,5 S. + 7,5 O.	
—— —— hydrate		60,5	52 O. S. + 8,5 W.	
—— chloride		78	44,5 S. + 33,5 C.	
—— muriate		86,5	52 O. S. + 34,5 M. A.	
—— nitrate		102,5	52 O. S. + 50,5 N. A.	
—— sulphuret				
—— sulphate		89,5	52 O. S. + 37,5 S. A.	
—— phosphate		77	52 O S.. + 25 P. A.	
—— carbonate		72,7	52 O. S. + 20,7 C. A.	
Calcium		19		The Salts of Lime furnish precipitates of carbonate of lime by the carbonated alcalies; they afford no precipitate with caustic ammonia. Oxalic acid, and oxalate of ammonia, produce precipitates of oxalate of lime, which, at a red heat, affords quicklime.
—— oxide		26,5	19 C. + 7,5 O.	
—— —— hydrate		35	26,5 O. C. + 8,5 W.	
—— chloride		52,5	19 C. + 33,5 C.	
—— muriate		61	26,5 O. C. + 34,5 M. A.	
—— chlorate		97,5	26,5 O. C. + 71 C. A.	
—— iode		136,7	19 C. + 117,7 I.	
—— oxyiodate		181,75	26,5 O. C. + 155,25 O. A.	
—— hydriodate		145,2	26,5 O. C. + 118,7 H. A.	
—— nitrate		77	26,5 O. C. + 50,5 N. A.	
—— sulphate		64	26,5 O. C. + 37,5 S. A.	
—— sulphuret				
—— phosphuret				
—— phosphate		51,5	26,5 O. C. + 25 P. A.	
—— biphosphate		76,5	26,5 O. C. + 50 P. A.	
—— carbonate		47,2	26,5 O. C. + 20,7 C. A.	
—— fluoride				
Hydrofluoric acid				
Fluoboric gas	32,68	to hydrog.		
METALS of SIXTH CLASS.				
Magnesium		11		The salts of magnesia are decomposed by solution of pot-
—— oxide		18,5	11 M. + 7,5 O.	

SUBSTANCES.	Specific Gravity.	Representative Number.	Composition.	REMARKS.
Magnesium hydrate .		27	18,5 O. M. + 8,5 W.	ash, and by its subcarbonate; the precipitate does not redissolve in excess of the alcalies, but readily dissolves in excess of sulphuric acid. The salts of magnesia are not precipitated by a solution of bicarbonate of potash (cold), nor by subcarbonate of ammonia; but if heat be applied, carbonic acid escapes, and the earth is precipitated in the state of subcarbonate. The salts of magnesia are only partially decomposed by ammonia, which forms triple salts with the earth and acid. Oxalate of ammonia does not precipitate magnesia.
——— chloride .		44,5	11 M. + 33,5 C.	
——— muriate .		53	18,5 O. M. + 34,5 M. A.	
——— chlorate .				
——— hydriodate .				
——— nitrate .		69	18,5 O. M. + 50,5 N. A.	
——— sulphite .				
——— sulphate .		56	18,5 O. M. + 37,5 S. A.	
——— carbonate .		39,2	18,5 O. M. + 20,7 C. A.	
——— bicarbonate .		59,9	18,5 O. M. + 41,4 C. A.	
Silicium . .		15		
Silicated fluoric gas .	4,92	to hydrog.		
Alumium . .				
Zirconum . .		35		
Yttrium . .				
Glucium . .				

PART IV.

Vegetable Chemistry.

This part of the science relates to the chemical changes which are observed during the germination and growth of plants; to the composition of vegetable substances; and to the phenomena and products of fermentation.

The seeds of plants consist of three distinct parts. 1. The exterior coat or membrane. 2. The cotyledons, which form the bulk of the seed. 3. The germ.

When a seed is placed under favourable circumstances for germination, the exterior coat bursts from the swelling of the cotyledons—the germ increases in size—it puts forth a *radicle*, which soon becomes a perfect root, and a *plumula* which forms the stem and leaves.

A due temperature, generally between 50° and 70°, a proper supply of moisture and access of air, are the essential requisites for perfect germination.

The oxygen of the atmosphere abstracts carbon from the principles of the cotyledons, by which saccharine matter is formed; this is absorbed by the vessels which, arising from the young germ, ramify through them, and tends to nourish the young plant until its roots are fit for their functions. Water is obviously required in these changes, which terminate in producing a plant with a root, stem, and leaves.

The leaves of plants, when exposed to the sun's rays, absorb carbonic acid from the atmosphere, and evolve oxygen. If healthy leaves, gathered on a warm dry day, be placed under a jar of air, it will be found that, during the night, those which are thick and fleshy absorb a portion of oxygen, while those which are thin and delicate absorb also oxygen, and evolve a portion of carbonic acid; which, upon exposure to the sun, they again decompose and restore the oxygen: So that thick leaves diminish the bulk of the air to which they are exposed during the night, and increase it in the day. M. de Saussure found the leaves of the *Cactus opuntia* especially adapted for these experiments. It is only the green parts of plants that exhibit these properties. The roots, wood, and flowers, simply evolve a small portion of carbonic acid. From manures and the soil plants absorb small quantities of saline and carbonaceous matter. The salts most commonly found in vegetables are carbonate, sulphate, and phosphate of potash, carbonate and phosphate of lime, phosphate of magnesia. We also find the chlorides of potassium and sodium, the oxides of iron and manganese, and silica.

Vegetable substances may be considered as consisting of ULTIMATE and PROXIMATE PRINCIPLES. Of the *ultimate principles* the most important are *Oxygen*, *Hydrogen*, *Carbon*, and *Nitrogen*. The three first exist in all vegetable bodies—the latter is confined to a few. To exhibit these elements, a vegetable substance, starch for instance, may be put into a small earthen retort, to which an earthen tube is attached, passing through a furnace, and slightly inclined. To the other extremity of this tube is annexed a receiver, whence a bent glass tube issues to convey the gaseous products to the mercurial trough. The earthen tube is heated to redness, and afterwards the retort is gradually raised to the same temperature—the starch is thus decomposed, and affords charcoal and water, carbonic oxide and acid, and carburetted hydrogen. Sometimes a little empyreumatic oil and acetic acid are formed, and if the vegetable contain nitrogen, there is more or less ammonia produced.

The *proximate principles* of vegetables may be arranged under four divisions, founded upon the nature and proportions of their ultimate components. In the first division are comprised those in which the relative proportion of the oxygen to the hydrogen is greater than in water. In the second, those in which the relative proportions of oxygen to hydrogen are the same as in water; in the third, those in which

Chemistry. there is excess of hydrogen; in the fourth, those which contain nitrogen.

The bodies contained in the first division are all acid, and as they are described in the Article CHEMISTRY of the *Encyclopædia*, it will here only be required to enumerate them.

1. *Acetic acid*, composed of

Carbon,	50,224
Oxygen and hydrogen in the proportions of water,	46,911
Excess of oxygen,	2,865
	100,000

2. *Oxalic Acid*, containing

Carbon,	26,566
Oxygen and hydrogen in the proportions of water,	22,872
Excess of oxygen,	50,562
	100,000

3. *Citric Acid*, containing

Carbon,	33,811
Oxygen and hydrogen as in water,	52,749
Excess of oxygen,	13,440
	100,000

4. *Tartaric Acid*, consisting of

Carbon,	24,050
Oxygen and hydrogen as in water,	55,240
Excess of oxygen,	20,710
	100,000

5. *Benzoic Acid.*
6. *Camphoric Acid.*
7. *Gallic Acid.*
8. *Malic Acid.*
9. *Suberic Acid.*
10. *Succinic Acid.*
11. *Mellitic Acid.*
12. *Saclactic Acid.*

To these the following have been lately added:

13. *Fungic Acid.* Discovered in certain fungi by M. Braconnot. It is deliquescent, uncrystallizable, colourless, and of a very sharp flavour. It forms with baryta a difficultly crystallizable salt, soluble in 15 parts of water at 60°; with potash and soda uncrystallizable deliquescent salts, insoluble in alcohol; with oxide of zinc a crystallizable salt. Added to acetate of lead it produces a white flocculent precipitate, soluble in distilled vinegar. (See *Annales de Chimie*, tom. 87.)

14. *Kinic Acid*, found in combination with lime in cinchona bark. (Vauquelin, *Annales de Chimie*, tom. 59.)

The law of definite proportions, as applied to salts of vegetable acids, has not been sufficiently investigated.

The substances of the second division contain oxygen and hydrogen, in the same relative proportions as in water. All these bodies are solid, heavier than water, inodorous, and without action on vegetable colours. Their properties are described in the *Encyclopædia* (Art. CHEMISTRY). They are, 1. *Sugar.* 2. *Gum.* 3. *Starch.* Iodine is an excellent test for starch. It produces a deep blue colour when added to its solutions. 4. *Lignin.** 5. *Tannin.* (See Mr Hatchett's papers on this subject, *Phil. Trans.* 1805.) 6. *Extractive.*

The third division contains bodies with excess of hydrogen; they generally abound in carbon, and are insoluble, or sparingly soluble in water. They are, 1. *Fixed Oil.* 2. *Volatile Oil.* 3. *Resin.* 4. *Caoutchouc.* 5. *Camphor.* 6. *Wax.*†

The fourth division contains one substance only, namely *Gluten;* which, when submitted to destructive distillation, affords products analogous to those of animal matter, and especially characterized by ammonia.

Besides the bodies which are comprehended in

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* MM. Gay-Lussac and Thenard have concluded, from their experiments on the wood of the oak and the beech, that 100 parts of the first contains:

Of carbon,	52,53	And 100 parts of the second:	Of carbon,	51,45
— oxygen,	41,78		— oxygen,	42,73
— hydrogen,	5,69		— hydrogen,	5,82

† From the experiments of Gay-Lussac and Thenard, it appears that olive oil contains, in 100 parts,

Carbon,	77,213	100 parts of common resin contain	Carbon,	75,944
Oxygen,	9,427		Oxygen,	13,337
Hydrogen,	13,360		Hydrogen,	10,719

Or of Carbon,	75,944
Oxygen and hydrogen in the proportions necessary to form water,	15,156
Hydrogen in excess,	8,900

According to the same chemists, 100 parts of copal consist of

Carbon,	76,811	Or,	Carbon,	76,811
Oxygen,	10,606		Water or its elements,	12,052
Hydrogen,	12,583		Hydrogen,	11,137

100 parts of wax consist of

Carbon,	81,784	Or otherwise,	Carbon,	81,784
Oxygen,	5,544		Oxygen and hydrogen in the proportions necessary to form water,	6,300
Hydrogen,	12,672		Hydrogen,	11,916

the preceding divisions, there are several other proximate principles of vegetables, the nature of which has not been sufficiently investigated, so as to enable us to class them according to their ultimate components; such as the narcotic principle of opium (*Annales de Chimie*, 1817), and the colouring matter.

Several different colouring principles have already been recognised, of which the principal are, 1. *Hematine*, the colouring matter of logwood, soluble in alcohol and in water. 2. *Carthamine*, from the flowers of the *Carthamus tinctorius*, insoluble in water and alcohol, but soluble in alcalies. 3. *Indigo*, insoluble in its ordinary state in water, alcohol, and alcalies, but soluble in sulphuric acid. By the action of certain substances which absorb oxygen, indigo becomes green, and, in that deoxydized state, is soluble in alcalies. M. Chevreul obtained from 100 parts of indigo of Guatimala the following results: (*Annales de Chimie*, Tom. 76. p. 29.)

Dissolved by water,	Green matter united to ammonia, a little deoxydized indigo, gum and extractive,		12
Dissolved by alcohol,	Green matter, red resin, and a little indigo,		30
Dissolved by muriatic acid,	Red resin,	6	10
	Carbonate of lime,	2	
	Red oxide of iron, Alumine,	2	
Residue,	Silica,		3
	Pure indigo,		45
			100

When indigo is heated, it sublimes in the form of a violet-coloured vapour, much resembling iodine, and condenses in crystals upon the cooler part of the vessels.

Phenomena and Products of Fermentation.

Under the articles CHEMISTRY, BREWING, MALTING, and VINEGAR-MAKING, in the *Encyclopædia*, will be found the leading technical and theoretical observations upon the subject of fermentation. The result of this process is the conversion of a portion or the whole of the sugar contained in the original liquor into alcohol. Different wines contain different portions of alcohol, according to the circumstances under which they have been made, and the composition of the juice of the grape or other materials employed. To ascertain the quantity of alcohol which any wine contains, its acid may be saturated with potash; a given measure is then to be distilled with a gentle heat, nearly to dryness, and the deficient bulk of the distilled liquor is to be made up with distilled water. This mixture is to be shaken and set aside for twenty-four hours. Its specific gravity will then show the quantity of alcohol which the wine contains, and which may be immediately seen by reference to Mr Gilpin's tables, published in the *Phil. Trans.* for 1794. The following table, taken from Mr Brande's paper in the *Phil. Trans.* for 1811, shows the relative quantity of alcohol contained in the principal wines, &c.

WINE.	Proportion of Alcohol, *per cent.* by Measure.	WINE.	Proportion of Alcohol, *per cent.* by Measure.
Port	21,40	White Hermitage	17,43
Ditto	22,30	Red Hermitage .	12,32
Ditto	23,39	Hock	14,37
Ditto	23,71	Ditto	8,88
Ditto	24,29	Vin de Grave .	12,80
Ditto	25,83	Frontignac . .	12,79
Madeira . . .	19,34	Coti Roti . .	12.32
Ditto	21,40	Rousillon . . .	17,26
Ditto	23,93	Cape Madeira .	18,11
Ditto	24,42	Cape Muschat .	18,25
Sherry . . .	13,25	Constantia . .	19.75
Ditto	18,79	Tent	13,30
Ditto	19,81	Sheraaz . . .	15,52
Ditto	19,83	Syracuse . . .	15,28
Claret	12,91	Nice	14,63
Ditto	14,08	Tokay . . .	9,88
Ditto	16,32	Raisin Wine . .	25,77
Calcavella . .	18,10	Grape Wine .	18,11
Lisbon . . .	18,94	Currant Wine .	20,55
Malaga . . .	17,26	Gooseberry Wine	11,84
Bucellas . . .	18,49	Elder Wine . .	9,87
Red Madeira .	18,40	Cyder	9,87
Malmsey Madeira	16,40	Perry	9,87
Marsala . . .	25,87	Brown Stout .	6,80
Ditto	17,26	Ale	8,88
Red Champagne	11,30	Brandy . . .	53,39
White Champagne	12,80	Rum	53,68
Burgundy . .	14,53	Hollands . . .	51,60
Ditto	11,95		

The most recent analysis of alcohol is by Mr Th. de Saussure (*Annales de Chimie*, t. 89), from whose researches it appears, that 100 parts, specific gravity 792, consist of

Carbon,	51,98
Oxygen,	34,32
Hydrogen,	13,70
	100

It is probable that pure alcohol, free from water, consists of

100 parts elements of olefiant gas.
50 —— ——— of water.

Ethers are formed by the action of certain acids upon alcohol. The distillation of equal weights of sulphuric acid and alcohol produces *sulphuric ether*, of which 100 parts, specific gravity 0,7155 at 68°, contain

Carbon,	67,98
Oxygen,	17,62
Hydrogen,	14,40
	100

Or deprived of adherent water, it may be considered as containing

100 parts elements of olefiant gas.
25 —— ——— of water.

So that the action of the sulphuric acid in converting alcohol into ether, consists in the removal of one-half of the elements of water which it contains, the proportion of the elements of olefiant gas remaining the same. If the whole of the elements of water be removed from alcohol, olefiant gas is the only result.

Nitric Ether is formed by gradually adding half a pound of nitric acid to two pints of alcohol contained in a glass retort. A pint and a half is to be distilled over by a very gentle heat, which, by redistillation with pure potash, affords nearly a pint of nitric ether. It is heavier than alcohol, and of a peculiar acrid flavour and fragrancy. Passed through a red-hot tube it affords water, prussic acid, ammonia, oil, charcoal, carbonic acid and oxide, carburetted hydrogen and nitrogen, and its oxides.

When equal parts of nitric acid and alcohol are mixed, a violent action soon ensues, and a copious evolution of *nitrous etherised gas* is the result.

If 100 parts of mercury, dissolved in a measured ounce and a half of nitric acid, be added to two measured ounces of alcohol, and a gentle heat applied, a violent action ensues, during which a whitish powder, which is fulminating mercury, is deposited. It was discovered by Mr Howard, according to whom it consists of oxalate of mercury combined with nitrous etherised gas. Berthollet considers it as containing ammonia, oxide of mercury, and a peculiar vegetable body.

Hydriodic Ether has been obtained by M. Gay-Lussac by distilling a mixture of alcohol and hydriodic acid. (*Vide Annales de Chimie*, t. 91.)

For an account of the remaining Ethers, and some other vegetable products not noticed here, the reader is referred to the article CHEMISTRY in the *Encyclopædia*.

PART V.

ANIMAL CHEMISTRY.

The decomposition of animal substances is in general attended by more complicated results than those of vegetables. Ammonia is produced in abundance by the greater number of them, and certain combinations of sulphur and phosphorus with the compounds of carbon, &c. as afforded by vegetable decomposition. Oxygen, hydrogen, carbon, nitrogen, sulphur, and phosphorus, may be considered as the most frequently occurring ultimate elements of animal substances, and these give rise to various compounds produced by their destructive distillation, such as water, subcarbonate of ammonia, prussic acid, &c. &c. Animal substances are decomposed with peculiar phenomena by the acids. Sulphuric acid carbonizes them, and produces water, ammonia, and oily matter; and if heat be applied, the acid is decomposed, and sulphurous gas disengaged. The action of nitric acid is attended by yet more complicated results; it gives rise to the formation of water, carbonic acid, nitrogen, nitrous oxide, nitrous, prussic, acetous, malic, and oxalic acids, ammonia, and a peculiar yellow detonating compound.

Heated with liquid fixed alcalies, animal substances afford ammonia, carbonic and acetic acids, and a peculiar body which forms a soapy compound; and in general, when ignited with potash or soda, cyanurets are formed, which, by the action of water, produce hydrocyanates (*prussiates*).

The proximate principles of animals have not yet been sufficiently investigated to enable us to arrange them according to their composition; they will be most conveniently examined as resulting from the chemical examination of the different products of animal bodies; these may be considered in the following order:

1. Blood.
2. Bile.
3. Milk.
4. Lymph.
5. Urine.
6. Cutis or skin.
7. Muscles, membranes, ligaments, horn, hair, &c.
8. Oil and fat.
9. Brain and nerves.
10. Shell and bone.
11. Concretions.

Blood.

This fluid, in the large arterial vessels of the more perfect animals, is florid red, and of a brownish red in the veins. Its specific gravity varies from 1083 to 1126. Its temperature is between 97° and 102°. When drawn from the circulating vessels, it undergoes a spontaneous change—forming a firm *coagulum* and a fluid *serum*. During this coagulation, there appears to be no increase of the temperature of the blood. (See Dr Davy's *Experiments. Journal of Science and Arts*, Vol. II. p. 247.)

Serum is a yellow fluid, of a specific gravity of 1029. At a temperature of 160° it coagulates into a firm whitish mass. Serum is also coagulated by alcohol, by most of the acids, and by the negative surface of the Voltaic pile. The substance in the serum which thus coagulates is called *Albumen*, a frequently occurring proximate principle of animals, and which exists in considerable purity in the white of egg.

Liquid Albumen is always slightly alcaline; it is soluble in water, and the solution furnishes a flocculent precipitate with corrosive sublimate, and muriate of tin; if not very dilute, it is also precipitated by the other coagulants of albumen. It soon putrifies at the temperature of 60°, and sulphuretted hydrogen is evolved. If dried by a heat between 100° and 120°, it forms a brittle transparent substance like amber.

Coagulated Albumen is insoluble in water; it does not putrify, but, exposed to dry warm air, it gradually becomes tough and semitransparent, and much resembles horn. When digested in water, it affords a weak alcaline solution of albumen. Submitted to destructive distillation, it affords products marked by abundance of ammonia, and a coal remains, very difficult of incineration. (See Mr Hatchett's Papers in the *Phil. Trans.* for 1799 and 1800.) Dr Marcet obtained the following results from the analysis of 1000 parts of the serum of human blood. (See *Medico-Chirurgical Trans.* Vol. II.)

Water, - - -	900,00
Albumen, - - -	86,80
Muriate of potash and soda, -	6,60
Muco-extractive matter, -	4,00
Subcarbonate of soda, - -	1,65

Sulphate of potash, - -	0,35
Earthy phosphates, - -	0,60
	1000

When serum or white of egg is coagulated by heat, there oozes from it a yellow fluid, which has been called *serosity*, and which consists of albumen, soda, and water. By washing the coagulum, almost the whole of the alcali may be separated; the acids, alcohol, and negatively electrified surfaces, also separate soda when they coagulate albumen. It appears, then, liquid albumen is a compound of soda and albumen with water; but that, after coagulation, the soda is found with the water, and the albumen solid and with scarcely any alcali.

The Coagulum or Crassamentum of Blood may be separated into two portions by copious washings with water; namely, into a white tough substance having all the essential characters of coagulated albumen, and which has been called *fibrine*, and into colouring matter.

The colouring matter diffused through the serum appears as a number of *red globules*, which in water part with their colour, and become white, and nearly transparent. In this state they appear to consist of albumen. The red substance is soluble in water, in muriatic, dilute sulphuric, acetic, tartaric, oxalic, and citric acids; the solutions are red by reflected, and green by transmitted light. Alcalies also form red solutions of the colouring principle. Nitric acid instantly destroys it.

Hence it appears that the blood consists of water, albumen, colouring matter, subcarbonate of soda, and certain saline substances, of which common salt is the principal. The cause of its spontaneous coagulation is unknown; the effect which we observe is the solidification of one part of the albumen with the colouring globules, forming the *crassamentum;* while another portion of the albumen remains fluid, constituting the *serum.*

Bile

Is a bitter greenish-yellow viscid liquid, secreted from venous blood in the liver; its specific gravity fluctuates between 1020 to 1030. The bile of the ox has been principally examined. It is alcaline. It soon putrefies, exhaling an insupportable stench. It dissolves in water, and is only imperfectly coagulated by alcohol, and by acids.

According to the analysis of Thenard (*Traité de Chimie*, p. 556, Vol. III.) bile consists of

Water, - -	700
Resinous matter, -	15
Picromel, - -	69
Yellow matter, - -	4
Soda, - - -	4
Phosphate of soda, - -	2
Muriates of soda and potash, -	3,5
Sulphate of soda, - -	0,8
Phosphate of lime and magnesia,	1,2
Traces of oxide of iron,	

Picromel is a principle peculiar to bile, of an acrid bitter and sweet taste, viscid consistency, and which forms a peculiar triple compound with the resin and soda. It is the substance which gives bile its leading characters. It may be obtained by adding to bile an excess of acetate of lead; it is then filtered, and subacetate of lead is added to the filtered liquor, a flocculent precipitate is formed, which is to be washed, and dissolved in distilled vinegar; a current of sulphuretted hydrogen passed through this solution separates the lead; the vinegar is then driven off by heat, and picromel remains.

The yellow matter is also peculiar to bile, and seems to render it easily putrescible.

Milk.

The gastric secretion of animals coagulates milk, and the cream having been separated, converts it into *curd* and *whey.* *

The curd or caseous part of milk (of the cow) is to be considered as a modification of albumen. The *whey*, by evaporation, affords *sugar of milk*, a white crystallizable substance, of a sweet taste, composed, according to Guy-Lussac and Thenard, of

Carbon, - -	38,825
Oxygen, - -	53,834
Hydrogen, - -	7,341

or of

Carbon, - -	38,825
Oxygen and hydrogen in the proportions of water, -	61,175

Butter, according to Braconnot, consists of 60 parts of yellow oil remaining fluid at low temperatures, and 40 parts of concrete oil.

Lymph.

This fluid, which lubricates the various cavities of the body, and which may be collected in considerable quantities, by puncturing the lymphatic vessels in large animals, has the properties of a weak solution of albumen; it contains the same salts as the serum of blood. The liquor of dropsies is also analogous in composition, but the proportion of albumen varies according to the circumstances under which it has been thrown out. In a case of hydrocele, which had been a long time forming, the liquor afforded a very small proportion (about 3 *per cent.*) of albumen. The sac filled in five days after the operation, and the fluid then contained 12 *per cent.* of albumen, and was readily coagulable by the usual means.

Urine.

This secretion is constantly varying in composition. It is when healthy always acid, but in cases of injury done to the nerves of the kidneys, it is alcaline. The following are the substances contained in human urine.

Water,	Uncombined, and giving acidity to the urine.
Carbonic acid,	
Uric acid,	
Phosphoric acid,	

* See Sir Everard Home on the *Coagulating Power of the Secretion of the Gastric Glands, Phil. Trans.* 1813. p. 96.

Muriate of soda.
Phosphate of soda.
Phosphate of ammonia and magnesia.
Phosphate of lime.
Muriate of ammonia.
Sulphates of potash and soda.
Urea.
Albumen. } Occasional ingredients.
Gelly.

Uric acid is occasionally deposited by urine in small red crystals; these are soluble in caustic alcalies, and the uric acid is precipitated from such solutions by muriatic acid. Boiling water dissolves about $\frac{1}{1100}$ of its weight of this acid. It is readily soluble in warm nitric acid, and the solution yields by evaporation a *rose red compound*, very characteristic of this acid.

Urea is the principle which gives to urine its leading peculiarity, that of affording abundance of ammonia during its putrefaction or decomposition by heat. It may be obtained by evaporating urine, voided about six hours after a meal, to the consistence of syrup; to which is to be added four times its weight of alcohol, and a gentle heat applied: the alcoholic solution, by evaporation in a water-bath, affords a crystalline residue of urea. This substance has an acrid taste, and urinous smell; it is soluble in water and alcohol; it forms with nitric acid a compound having the appearance of pearly scales. By heat, it affords two-thirds its weight of subcarbonate of ammonia, and a considerable portion of benzoic acid. Ammonia and acetic acid are the products of the decomposition of its aqueous solution: hence the production of various ammoniacal salts in putrid urine. Alcalies decompose urea, and exhale ammonia. It consists, according to Vauquelin and Fourcroy, of

Nitrogen,	-	32,5
Oxygen,	-	28,5
Carbon,	-	14,7
Hydrogen,	-	11,8

Cutis.

The cutis, or *true skin* of animals, consists principally of gelatine, a substance soluble in water, and forming a solution, which, if concentrated while hot, gelatinises on cooling. The solution affords a copious precipitate with vegetable astringents, and with nitrate of mercury it deposits white flocculi with solution of chlorine. Gelatine is soluble both in acids and alcalies. It is insoluble in alcohol, which precipitates it from its aqueous solution. Isinglass, size, and glue, are varieties of gelatine. It contains, according to Thenard and Gay-Lussac,

Carbon,	-	47,881
Oxygen,	-	27,207
Hydrogen,	-	7,914
Nitrogen,	-	16,998

When submitted to destructive distillation, it affords the usual products of animal bodies. When dry, it suffers no change by exposure to air, but its solution very soon putrefies. *

Muscular Flesh, &c.

When the *muscular parts* of animals are washed repeatedly in cold water, the fibrous matter which remains consists chiefly of albumen, and is in its chemical properties analogous to the clot of blood. Muscles also yield a portion of gelatine, and the flesh of beef, and some other parts of animals, afford a peculiar substance of an aromatic flavour, called by Thenard *osmazome. Ligaments, horn, nail, feathers*, and *the cuticle*, consist principally of albumen. *Elastic ligament and tendon* yield a portion of gelly. The *membranes* consist principally of gelatine.

Hair consists principally of a substance, having the properties of coagulated albumen. It also contains gelatine, and the soft kinds of hair yield it more readily than those which are harsh, strong, and elastic.

Vauquelin discovered in hair two kinds of oil; the one white, and existing in all hair, the other coloured, yellow from red hair, and dark coloured when obtained from dark hair. Black hair also contains iron and sulphur. He supposes that where hair has become suddenly grey, the effect is produced by the evolution of acid matter, which has destroyed the colour of the oil.

Oil and Fat.

These proximate principles contain no nitrogen. They are compounds of carbon, hydrogen, and oxygen, in which the two former elements abound. These bodies have lately been laboriously investigated by MM. Chevreul and Braconnot (*Annales de Chimie*, Tom. 88, 93, 94, and 95). The different kinds of fat are separable into two substances, one of which fuses at about 50°, the other at 105°. They may be separated from hogs-lard, for instance, by boiling in seven or eight times its weight of alcohol; the liquor is decanted, and fresh alcohol added, till the whole is dissolved. Each portion of alcohol deposits, on cooling, crystals of the least fusible substance; the other is obtained in the form of oil, by evaporating the mixed alcoholic solutions to one-eighth their original bulk. The reunion of these two principles produces the original fat. By exposing oils solidified by cold to pressure, they too afford a fluid and solid matter. The following are the relative proportions of oil and fat afforded by several of these substances:

	Oil.	Fat.
Butter made in summer, -	60	40
Ditto made in winter, -	37	63
Hogs-lard, - - -	62	38
Beef marrow, - -	24	76
Mutton ditto, - -	74	26
Goose fat, - - -	68	32
Duck's fat, - - -	72	28

* Mr Hatchett's admirable Dissertations in the *Phil. Trans.* 1800 and 1799, contain a great body of information in this department of animal chemistry. The reader is also referred to Dr Bostock's papers i Nicholson's *Journal*, Vol. XI. and XIV.

	Oil.	Fat.
Turkey's fat, - -	74	26
Olive oil, - - -	72	28
Almond oil, - - -	76	24

The fat is fusible at different temperatures, and the fluid part of olive and almond oil requires a very low temperature for its solidification; so that it may perhaps prove very useful for watches and clocks. Chevreul calls the oily part *elaine*, from ελαιον, oil, and the fat substance he terms *stearine*, from στεαρ, suet.

When fat is acted upon by alcalies, it suffers a change by which it affords a peculiar substance of a pearly lustre, called by Chevreul *margarine*, and an oily matter. A sweet substance, a volatile, and an orange-coloured substance, are also produced. Margarine has acid properties, and exists in soap, as *margarate of potash.*

Brain and Nerves.

According to Vauquelin, the cerebral substance consists of

Water, - -	80,00
White fatty matter, -	4,53
Red fatty matter, -	0,70
Albumen, - -	7,00
Osmazome, - -	1,12
Phosphorus, - -	1,50
Acids, salts, and sulphur, -	5,15
	100

The pulp of nerves seems to be of a similar nature.

Shell and Bone.

These may be considered as containing an animal substance or hardening matter. The animal substance in porcellaneous shells, and in the enamel of teeth, is gelatine; in mother of pearl shell, and in bone, it is a compound of gelatine and albumen; and, consequently, the former are entirely dissolved by dilute muriatic acid, while the latter leave a cartilaginous skeleton. The hardening principle of shell is generally carbonate of lime; in some *crustacea* and *zoophites* it is a mixture of carbonate and phosphate of lime; and in bone it consists of phosphate of lime, with a relatively small proportion of carbonate. (See Mr Hatchett's Papers, *Phil. Trans.* 1799 and 1800.)

Concretions.

Concretions occur in various parts of the animal body; they are often of the same composition as bone, as in the case of ossifications and exostoses.

Concretions of the gall-bladder, and biliary ducts, consist chiefly of a peculiar substance called adipocire, or *cholesterine,* combined with from 6 to 12 *per cent.* of the colouring matter of bile. Picromel, which is not found in healthy human bile, occasionally occurs in human biliary calculi. Gallstones sometimes contain a large quantity of the resin of bile, and sometimes appear to consist entirely of inspissated or thickened bile.

Urinary calculi vary considerably in their composition. The substances hitherto discovered in them are as follow:

Uric acid.
Phosphat of lime.
Ammoniaco-magnesian phosphate.
Oxalate of lime.
Cystic oxide.

These substances are generally more or less mixed in urinary calculi, and their different kinds may therefore be arranged as follow:

1. *Uric calculus.*
2. *Bone earth calculus,* consisting chiefly of phosphat of lime.
3. *Ammoniaco-magnesian,* or *triple phosphate.*
4. *Fusible calculus,* consisting of a mixture of the two last.
5. *Mulberry calculus,* or oxalate of lime.
6. *Cystic calculus,* consisting of a peculiar substance, which Dr Wollaston has called *cystic oxide.* (See *Phil. Trans.* 1810.)

The properties of the four first calculi will be obvious from the preceding matter of this article. The calculus composed of oxalate of lime, when in the bladder, has much resemblance to a mulberry; when formed in the kidney, it often looks like a hempseed. Before the blow-pipe it affords quicklime. The cystic oxide is dissolved by muriatic, nitric, sulphuric, phosphoric, and oxalic acids; by potash, soda, ammonia, lime-water, and carbonates of soda and potash. Its combinations with the acids crystallize in slender needles; those with the alcalies in small grains. It is nearly insoluble in water, alcohol, acetic, tartaric, and citric acids, and in carbonate of ammonia.

The above substances, excepting cystic oxide, are often in alternate layers in calculi, and two or more are sometimes mixed so as not to be separable except by analysis. Urinary calculi have been found in the horse, composed of phosphate and carbonate of lime; in the ox, of carbonate of lime; in the dog, of a mixture of phosphate of lime and triple phosphate; in the hog, of carbonate of lime; in the rabbit, of phosphate and carbonate of lime. In the excrements of the Boa constrictor, and of some birds, uric acid is found. Independent of hair balls, calculi are sometimes found in the intestines of animals, composed of triple phosphate and phosphate of lime.

Gouty concretions consist of urate of soda.

Upon the subject of urinary calculi, the reader is referred to Dr Wollaston's Dissertations in the *Philos. Trans.* 1797—1810; to Mr Brande's papers in the same work; and to an *Essay on the Chemical History and Medical Treatment of Calculous Disorders,* by Alexander Marcet, M. D.

Animal Functions.

Under this head, the processes concerned in the productions of animal substances are considered in the article Chemistry in the body of the work. These processes may be considered under the heads *Digestion, Transpiration, Respiration,* and *Secretion.*

The food, masticated in the mouth, is mixed with

saliva, a fluid containing saline matter and albumen, and thus propelled into the stomach, where it becomes converted into a peculiar pulpy mass called *chyme*. This change appears principally dependent upon the *gastric juice*, which, by analysis, does not greatly differ from saliva, and yet produces very different effects. The nature of its action is not known. In the small intestines, the chyme is mixed with bile and pancreatic secretion; and hence *chyle* is formed, which, absorbed by the lacteals, and mixed with lymph, is carried into the venous system. Human chyle has not been examined: from the dog and cat it is a white fluid, of a slightly sweet taste, and coagulates soon after removal from its vessels. Its principal component part is albumen; and sometimes the serous part of chyle contains a body analogous to sugar of milk. The chyle of graminivorous animals is more transparent than the former, and nearly colourless; it coagulates spontaneously, and the coagulum is albuminous.

The matter which is transpired by the surface of the body consists of water, carbonic acid, acetic acid, phosphoric acid, muriate of soda, and a peculiar odorous animal matter. By the process of respiration, the blood is exposed to the action of air in the lungs. Having circulated throughout the body, it enters by the venæ cavæ with the contents of the thoracic duct, into the right auricle of the heart; thence into the right ventricle, whence it is propelled through the lungs, and returns in the state of arterial blood to the left cavities of the heart, and is circulated as before. In the air expired, there is a deficiency of oxygen; instead of containing 21 *per cent*., it only affords 18 or 19; and there is a proportion of carbonic acid formed, exactly equivalent in volume to this deficiency. Aqueous vapour is also exhaled with the expired air. It appears, then, that the great end answered by respiration is the removal of carbon from the blood; it thus passes from the state of venous to arterial; it becomes fit for the nourishment, and reproduction of parts, and for the formation of secretions; and, while the parts of the body are continually removing by the absorbents, and the materials carried into the blood by the lymphatics, so they are constantly reproducing by the arteries, under the influence of the nervous system. It is probable that the colouring matter of blood remains always the same, and that in venous blood it is obscured by carbon, which, when removed by the air, exposes its brilliant tint, as seen in arterial blood, or in venous blood which has been exposed to oxygen. The nervous system seems to preside over secretion; for, when the nerves going to any gland are injured or divided, the secretion is modified either in quantity or quality; and, if it were possible to remove the nervous ramifications altogether, probably no secretion would take place. Animal heat is also the effect of the joint agency of the circulating and nervous system; for, when the great centre of nervous energy, the brain, is removed, there is no production of heat, though, under such circumstances, circulation may be kept up by artificially continued respiration, for a considerable period. Upon these subjects, however, which are rather physiological than chemical, we refer our readers to the researches of Sir E. Home (*Phil. Trans*. 1814), and to Mr Brodie's papers in the *Philos. Trans*. for the year 1811.

(M. M.)

CHENIER (Marie Joseph de) was the son of Louis Chenier, well known as the author of *Recherches Historiques sur les Maures*, and *Revolutions de l'Empire Othoman*. He was born in 1764, at Constantinople, where his father at that time acted as Consul General from France. At a very early period of life he entered into the French army, but he soon relinquished the military profession, and settled at Paris, where he devoted much of his time to literary pursuits. He commenced his dramatic career by a tragedy, which was acted in 1786, and was completely unsuccessful. A few years afterwards, availing himself of the political feelings of the period, he produced the tragedy of Charles IX., which was received with vast applause by the party which predominated at the time. This was followed by *La Mort de Calas*, and the republican tragedies of *Gracchus* and *Timoleon*. These dramas, in a great measure, owed their popularity to existing circumstances, and the author's talent of addressing himself to the prevailing feelings of the multitude. His performances, however, were instrumental in procuring him a seat in the National Convention, and obtained him the highest theatrical reputation, till he unfortunately brought forward a tragedy founded on the accession of Cyrus to the throne of the Medes, a subject which, as it gave less scope to political allusion than his former productions, and had been previously treated with greater ability by other writers, failed more completely even than the piece with which he first laid claim to the favour of the public. After this failure Chenier appears to have distrusted his dramatic genius, and chiefly employed himself in translating or imitating the most celebrated productions of the Greek and German stage.

Chenier, however, did not confine himself to dramatic compositions, but cultivated almost every species of poetry with tolerable success. His productions are chiefly satirical, lyric, and political. Being engaged in a variety of literary as well as political quarrels, and being naturally of a haughty irritable temper, he was naturally led to employ his talents for poetry and satire on all who had provoked his enmity. His works of this description, accordingly, are often misapplied, but are distinguished by considerable gaiety and energy of composition. His lyric productions, of which he published a collection in 1797, consist partly of odes imitated from the *Poems of Ossian*. Most of his other poems, as his *Poeme sur l'Assemblée des Notables* and *Dithyrambe sur l'Assemblée Nationale*, allude entirely, as their name imports, to the political events of the day.

Chenier || Cheshire.

Chenier also distinguished himself as a prose writer by his productions in the *Mercure de France*, and the discourses which he prepared for the different academies of which he was a member. which chiefly turn on subjects connected with the progress of knowledge in Europe, and the literary history of his own country. In consequence of a task assigned by Bonaparte to the Institute, of which Chenier was a member, he undertook to give a historical and critical account of the most celebrated productions, both in prose and verse, which had enriched French literature from the year 1788 to 1808. This sketch was originally read at one of the sittings of the Institute, and was afterwards published under the title *Tableau Historique de l'etat et des progrés de la Litterature Francaise depuis* 1789. This work comprehends a notice of all the best works which had appeared during that period, from the light class of romances to the most important treatises on morals, politics, and legislation; and in poetry it embraces a review from the highest epic to burlesque and mock heroic.

Many of the orations and discourses pronounced by Chenier in the different political assemblies which were formed during the existence of the French republic, and of almost all which he was a member, related to similar topics—proposals for legislative measures with regard to literary works—the encouragement of arts and systems of public instruction. Those orations, which were truly political, breathed all the violent spirit of the time and of the assemblies in which they were delivered. As he took an active part in the distracted politics of his country, and was engaged, on one side or other, in most of the revolutions by which she was at that time agitated, his character was frequently the object of the blackest calumnies, his property of confiscation, and his person of proscription. All this was little favourable to literary improvement. But, when France at length settled under the absolute dominion of one ruler, by being precluded from political intrigue and discussion, he had ample leisure left for study and composition. He continued thus usefully employed, in a state of comparative tranquillity, till his death, which happened at Paris, on the 10th January 1811.

The character and writings of Chenier partook strongly of the spirit of the times in which he lived. The former was marked by turbulence, restlessness, and ambition; and although some of his poems, as well as his more recent prose compositions, show that his taste was not naturally that of the school of the French Revolution, yet many of his tragedies and literary discourses are disfigured by that exaggeration of sentiments and ideas, as well as that declamatory and inflated style, which the tone and feelings of the period had introduced or propagated. (M.)

Boundaries. CHESHIRE is divided from Lancashire by the rivers Mersey and Tame; from Derbyshire and Staffordshire by the rivers Goyt and Dane, and a range of hills; and in a great measure from Flintshire and Denbighshire by the river Dee and its estuary, a small portion of the hundred of Broxton lying to the west of this general boundary. The form of this county is singular, being distinguished by two points, projecting, the one into the Irish Sea, between the Mersey and the Dee, which constitutes the hundred of Wirral; and the other running up towards Yorkshire, between Lancashire and Derbyshire, forming the extremity of the Macclesfield hundred. If these points were cut off, the figure of Cheshire would approach nearly to that of an oval.

Extent. The greatest breadth of this county, from north to south, is about 30 miles; its greatest length, from the extremity of the hundred of Wirral, at Kiddington Green, to Britland Edge, on the borders of Yorkshire, is 58 miles; across the middle part of the county, however, the length is not 40 miles. The projection between the Dee and Mersey is about 20 miles long and 6 broad; and that towards Yorkshire about 15 miles long, and seldom above 3 miles broad.

Divisions. Cheshire contains one city, which is also the county town, Chester; seven hundreds; thirteen market towns, including Chester; namely Stockport, Knutsford, Altringham, Congleton, Frodsham, Macclesfield, Malpos, Middlewich, Nantwich, Neston, Northwich, Sandbach, and Tarporley; and eighty-six parishes. As, however, many of these parishes are of great extent, and comprise numerous townships, and more than one chapelry having the privilege of baptism and sepulture, the number of parishes and places assessed to the poor's-rates, and other county and parochial rates, amounts, according to the last returns, to 491. This county is in the province of Canterbury, and diocese of Chester; within this diocese are comprehended Cheshire, Lancashire, and part of Yorkshire, Denbighshire, Flintshire, Westmoreland, and Cumberland. It is a county palatine, and is not included in any of the circuits, having a chief-justice of its own.

Surface. The area of Cheshire comprises about 1200 square miles, or 676,600 acres, of which a much larger proportion is in cultivation than in most other English counties; there being only 28,600 acres of waste land, commons, and woods; 18,000 in peat bogs and mosses; and 10,000 in sea sands, between the estuaries of the Dee and Mersey; the remainder, 620,000 acres, is in cultivation. The general character of the surface is flatness; the principal hills are on the borders of Derbyshire, which are connected with those of that county and Staffordshire; and stretch along the eastern side of the parishes of Astbury, Prestbury, and Motbram, about 25 miles. Near Frodsham, there is a bold promontory, overlooking the Mersey, which is the first of an interrupted ridge of hills that crosses the county from north to south, on its western side, as far as Malpos; this high ground, after crossing the elevated district of Delamere forest, appears again in the insulated rock of Beeston, which is nearly 386 feet in height. The last link on this chain of hills are those of Broxton. The ground near Macclesfield is also elevated. With these exceptions, and that of a low chain of hills stretching from north to south through the hundred of Wirral, Cheshire is more uniformly flat than any other county in this part of England.

Soil. There is not much variety of soil; sand and clay, with one or the other predominating in various proportions, constitute the soil of nearly the whole of Cheshire: that part of the county which stretches towards Yorkshire consists principally of peat moss;

Cheshire. a soil which also prevails to a less considerable extent near Coppenhall and Warmincham, and in some parts of the forest of Delamere; the greater part of the forest, however, consists of sterile white sand or gravel. The most prevalent subsoils are marl, clay, and redgrit rock, or sandstone.

Timber. Cheshire, viewed from a height, appears covered with wood; but this appearance arises from the smallness of the enclosures, and the great number of large trees in the hedge-rows; otherwise it is not a well-wooded county. Its forests, which formerly were extensive, consisted of those of Delamere, Macclesfield, and Wirral; the first contained 10,000 acres, 2000 of which have been enclosed. The quantity of timber in the hedge-rows and coppices exceeds the general average of the kingdom; the best as well as the most common is oak. In Dunham Park, near Altringham, the seat of the Earl of Warrington, there are some remarkably large old oaks. Alderley Park is equally celebrated for its beech trees.

Rivers. The principal rivers are the Dee, the Weaver, the Dane, and the Tame; the Mersey, though frequently described as a Cheshire river, seems to us more properly to belong to Lancashire. The Dee, which rises in Wales, enters this county near Aldford; from Bangor Bridge it is navigable for barges; at Chester Bridge it meets the tide; at Chester a ledge of rocks runs across the bed of the river; from this place to the sea, its natural course forms a broad sandy estuary; but an artificial channel has been formed at great expence, on the south side of the river, nearly half way to the sea, which is navigable for ships of 600 tons burden. It falls into the Irish Sea, about fourteen miles north-west of Chester. At the time when the artificial channel was made, much land was gained from the tide by embankments, and much has been subsequently recovered. The Weaver rises in Cheshire on Bulkley Heath, and flows entirely through the county, till it joins the Mersey at Wyton; from Frodsham Bridge to Winsford Bridge, a distance of 20 miles, it is rendered navigable by means of locks and wears; the fall is 45 feet 10 inches, and there are 10 locks; the course of this river is about 33 miles. The Dane rises in Macclesfield forest; during the first part of its course, it divides Staffordshire and Cheshire; at Congleton it enters the latter, and falls into the Weaver at Northwich: its course is about 22 miles. The character of these rivers differs much. The Weaver is narrow, deep, and slow; the Dane is broad, shallow, and swift. The Tame rises in Yorkshire; during the greater part of its course, which is only ten miles, it forms the boundary between Cheshire and Lancashire, and falls into the Mersey near Stockport.

Canals. Cheshire is intersected by the Duke of Bridgewater's canal; the Grand Trunk; the Ellesmere; the Chester and Nantwich, and the Peake Forest. The first runs through about twenty miles of the county, entering it to the east of Ashton, and joining the Mersey at Runcorn. The Grand Trunk canal communicates with the Duke of Bridgewater's at Preston-Brook, and passing by Northwich and Middlewich, enters Staffordshire near Lawton. There are four tunnels in the course of this canal through Cheshire, one of which, near Preston-on-the-Hill, is 1241 yards in length, 17 feet 4 inches in height, and 13 feet 6 inches in width. The Ellesmere canal joins the Mersey at Whitby, and after passing the east end of the Hundred of Wirral, and the south-east of Broxton, it connects with the Dee and the Chester canal at Chester: another branch forms a junction with the Chester canal at Hurleston. The Chester canal begins at the Dee, on the north of Chester, and passing through Christleton, Warriton, Hargrave, and to the north of Beeston Castle, terminates at Nantwich. The Peake Forest canal joins the Ashton and Oldham canal at Ashton-under-Line; it crosses the Tame near Duckinfield, and passing through Hyde, Marple, and Disley, enters Derbyshire near Whaley Bridge. Near Marple it is carried over the Mersey by an aqueduct of three arches and 100 feet in height. In the northern parts of Cheshire there are several small lakes called *Meres*.

Minerals. The mineral productions of this county are coal, copper, lead, cobalt, and rock-salt. Coal abounds in the north-eastern parts, in a district of about ten miles from north to south; there are also some coalieries in the Hundred of Wirral, one of which extends $1\frac{3}{4}$ mile from high water-mark under the river Dee. Copper, lead, and cobalt, are found at Alderby Edge, and copper in the Peckforton Hills; but none of these ores are by any means abundant.

Salt Springs. As the rock-salt and the brine-springs of Cheshire are naturally connected, and are found in the same districts, we shall consider them together. The brine-springs are principally met with in the valley through which the Weaver and the Wheelock flow; those from which salt is at present manufactured are at Lawton, Wheelock, Roughwood, in the townships of Anderton, Bechton, Leftwich, Middlewich, and in the neighbourhood of Northwich and Winsford. The brine-springs at Wheelock are at the depth of 60 yards. The brine is rich, but varies in strength; the strongest brine-springs are those of Anderton; those at Leftwich are the weakest.

The brine-springs of Cheshire were probably known to the ancient Britons. It is certain that salt made from them was one of the principal articles of the commerce of this county before the Norman Conquest. The discovery of the rock-salt, on the other hand, is very recent; not having been made till 1670, during a search for coal, near Northwich. Since that period it has been found abundantly in the townships of Witton, Wincham, and Marston. The rock-salt is met with at various depths below the surface, from 28 to 48 yards; some of the strata are only four feet thick, and others 40 yards. In the mines near Northwich there are only two beds of rock-salt; but in other parts three beds have been found. These beds are divided from one another by strata of indurated clay or hard flag-stone, in which there are frequently found pieces of rock-salt. The muriate of soda, in the great body of the rock-salt, is mixed with a considerable portion of clay, oxide of iron, and sulphate of lime. In the lower strata, the rock-salt is a purer muriate of soda. The rock-salt is extremely hard, and in many cases

Salt Mines.

Cheshire.

requires to be blasted with gunpowder. The largest mine at present worked is that of Wilton; its depth is 330 feet, and its area nearly two acres; the ceiling, which is about 20 feet high, is supported by pillars 15 feet thick, each containing 294 solid yards of rock-salt. Fifty or sixty thousand tons of rock-salt are obtained annually from the pits in the neighbourhood of Northwich, which is the great seat of the salt trade in this county. One-third of the rock-salt is dissolved in water and crystallized by evaporation, and two-thirds are exported in its native state.

By the Report of the Committee of the House of Commons, on the use of rock-salt in the fisheries, printed May 1817, it appears, that the capital embarked in the salt trade of Lancashire and Cheshire is about L. 600,000; that on an average of five years to the 5th of April 1817, 240,000 tons of white salt had been made annually in these two counties; that from 300 to 330 flats and barges are employed in conveying the salt; that 267 people are employed in the salt mines; that 6500 are employed in the manufacture of salt; and that 400 tons of iron are consumed annually in this manufactory.

Quarries.

Quarries of excellent freestone are found at Runcorn, Manley, and Great Bebington; limestone only at Newbold Astbury; millstones at Mowcop Hill; and sandstone fit for glass near Macclesfield. Marl abounds in almost every part of the county.

Landed property is, in general, very little divided in this county; there being, according to Mr Holland, fifty noblemen and gentlemen who possess in it property of the annual value of from L. 3000 to L. 10,000 a-year; and at least as many others with estates of from L. 1000 to L. 3000 a-year.

Cheese.

With respect to agriculture, Cheshire is almost entirely a dairy county: its arable husbandry is neither extensive nor of superior character. The principal dairies are about Nantwich, and in the district between the Dane and the Weaner; they are found, however, in every part of the county where the soil consists of clay. The number of cows kept for the dairy is about 32,000; and the quantity of cheese annually made about 11,500 tons. The average quantity of cheese from each cow annually is estimated at 300 lb.; eight quarts of milk, the average daily quantity yielded by each cow, producing one pound of cheese. In Lyme Park there is a herd of cattle of the same wild breed as those at Chillingham in Northumberland.

Potatoes.

The ground in the vicinity of Frodsham and Altringham produces abundant crops of excellent potatoes; in the latter parish, where sea-mud is used, 100,000 bushels are generally grown annually.

Manufactures.

The cotton manufactures of Lancashire have extended into the contiguous parts of Cheshire, particularly at Stockport. Silk is manufactured at Macclesfield and Congleton, where there are large silk-mills; hats at Stockport; white and red lead at Chester; and gunpowder at Tholwall. Tanneries are very numerous, and on a large scale, in the middle and north of the county.

Poor-Rates.

In 1803, the poor-rates amounted to L. 84,991. In 1815, 434 parishes and places paid the sum of L. 125,630. There were no returns from 57 places. In 1801, the number of inhabited houses was 34,482, and of uninhabited 1139. The total number of inhabitants was 191,751. Of these, 92,759 were males, and 98,992 females: 38,823 were employed in agriculture, and 67,447 in trade, manufactures, and handicrafts. According to the returns in 1811, there were,

Cheshire ‖ Chili.

Population.

Inhabited houses,	41,187
Families inhabiting them,	44,502
Houses building,	250
——— uninhabited,	1,239
Families employed in agriculture,	16,396
——— in trade, manufactures, and handicrafts,	23,043
——— not included in these classes,	5,063
Males,	110,841
Females,	116,190
Total,	227,031
Population in 1801,	191,751
Increase,	36,280

See Holland's *Agriculture of Cheshire.*—*Beauties of England and Wales*, Vol. II.—Lyson's *Magna Britannia*, Vol. II. Part II. (c.)

Boundaries and Extent.

CHILI. Some account of this country will be found in the *Encyclopædia*, to which the reader is referred for various particulars relative to its early history and its trade.

Chili is situated on the western shore of South America, between the 24th and 45th degrees of south latitude. It is estimated to stretch along the shore 1260 miles; but its breadth varies as the great chain of the Cordilleras, which forms its eastern boundary, approaches the sea, or recedes from it. Between the 24th and 32d degrees of south latitude, the space between the mountains and the Pacific Ocean, which forms the breadth of Chili, is about 210 miles. From the 32d to the 37th it is only 120; and near the archipelago of Chiloe, at the broadest part of Chili, it extends to 300 miles in breadth. On these data, the superficial extent of Chili may be estimated at 378,000 square miles.

Chili is separated from Peru on the north, from the viceroyalty of Buenos Ayres on the east, and from the land of Magellan on the south, by the Cordilleras, which form an almost insurmountable barrier between it and the neighbouring countries. The roads which lead across these lofty ridges are impassable except in summer, and the path is frequently so narrow, that a horseman can with difficulty effect a passage through it.

Divisions.

Molina, in his valuable account of this country, describes it under three great natural divisions. The first comprehends the islands; the second, Chili properly so called; and the third includes the Andes, or that part of Chili which is occupied by these mountains.

1. The islands belonging to Chili are, the three Coquimbanes, Mugillon, Totoral, and Pajaro, which last is about six or eight miles in circumference, and wholly desert; the two islands of Juan Fernandez, known under the name of Isola di Terra, and Massafuera, the former 42 miles in circumference, and inhabited by the Spaniards, the latter, though described as bearing the most inviting aspect, still

Chili.

uninhabited; and the island of Mocha, about 60 miles in circumference, and at present uninhabited, besides several other islands of inferior size and importance. The archipelago of Chiloe comprehends 82 islands inhabited by the Spaniards. Chiloe, which is the largest of these, and gives name to the archipelago, is 150 miles in length, and its capital is Castro. All these islands are adjacent to the coast, with the exception of those of Juan Fernandez, which are distant the one 330, and the other 420 miles from the shore.

2. That part of Chili which lies between the Andes and the sea, is divided into two equal parts, namely, the maritime country, and the midland country. The former of these is intersected by three chains of mountains running parallel to the Andes, with numerous intervening valleys, watered by delightful streams. The midland country is flat, being diversified only by a few occasional eminences, which render its appearance extremely picturesque and pleasing.

3. The Chilian Andes consist of a number of mountains, which appear to be chained to each other. They are of prodigious height, and are covered with perpetual snow. At the foot of this vast ridge, gentle eminences and pleasant valleys, surrounded with high hills, are dispersed; but the principal ridge rises in general, abrupt and steep, with frequent and frightful precipices. In these lofty mountains are formed many brooks and rivers, which, when they are swollen by the melted snows, quickly accumulate into formidable torrents, and roar and foam amid glens and precipices, until they break out and extend over the plains. The lower ranges of mountains are covered with forests, and the vales beneath abound in corn and fruit. That portion of the Chilian Cordilleras which lies between the 24th and 33d degree of latitude is wholly desert; but further to the south, as far as the 45th degree, the mountains are inhabited by a variety of Chilian tribes.

Spanish part of Chili.

Chili is partly occupied by the Spaniards, and partly by the Indians. The Spanish part of it is situated between the 24th and 37th degrees of south latitude, and is divided into the following thirteen provinces:

NAME.		Length. *Miles.*	Breadth. *Miles.*	CAPITAL.	S. Lat.
Copiapo	extending from Andes to the sea	300	210	Copiapo	26° 50′
Coquimbo	ditto - - -	135	210	Coquimbo	29° 54′
Quillota	situated on the sea coast -	75	63	Quillota	32° 56′
Aconcagua	in the vicinity of the Andes	75	75	Aconcagua	32° 48′
Melipilla	on the sea coast	33	69	Melipilla	33° 32′
Santiago	near the Andes - -	33	60	Santiago	33° 31′
Rancagua	from the Andes to the sea -	39	120	Rancagua	34°
Colchagua	from the Andes to the sea -	45	129	St Fernando	34° 18′
Maule	from the Andes to the sea -	132	144	Talca	34° 33′
Itata	on the sea coast - -	33	66	Coulemu	36° 2′
Chillan	near the Andes - -	36	75	Chillan	36°
Puchacay	on the sea coast - -	36	75	Gualqui	36° 42′
Huilquilemu	near the Andes - -	36	75	Huilquilemu	36° 42′

The territory belonging to the Indians is situated between the 36th and 41st degrees of S. Lat. and is inhabited by three different nations, namely, the Araucanians, the Cunches, and the Huilliches. Of the remarkable people called *Araucanians*, we have given a full account under that Article.

Soil and Climate.

Chili is blessed with a fertile soil, and with a mild and temperate climate; the air is remarkably salubrious, and the inhabitants are liable to few contagious diseases. They are, on account of these favourable circumstances, extremely attached to their native country, and always reluctant to quit it. Although the climate is not liable to either extreme of heat or cold, the different seasons regularly succeed each other, and are sufficiently marked. The spring commences, as in all countries in the southern hemisphere, in September, the summer in December, the autumn in March, and the winter in June. From the beginning of spring until autumn the south and south-east winds generally prevail, and they always bring with them a clear sky, while the north and north-west winds as regularly occasion rain. On the eastern and western sides of that great mountainous barrier which bounds Chili on the east, the dry and rainy seasons occur at precisely opposite periods. In Chili, the winter is the rainy season, while on the eastern side of the mountains, in the provinces of Tucuman and Cuyo, the atmosphere is then always clear, and the inhabitants enjoy the finest season. The north and northerly winds crossing the torrid zone before they arrive in Chili, come loaded with vapours, and they are invariably followed with heat and rain. In Chili the heat of these winds is moderated in their passage over the Andes; but in the countries to the east, they are remarkable for their sultry and unhealthy properties, and are, according to the account of Molina, more suffocating than the sirocco which blows from Africa, and is occasionally felt on the shores of the Mediterranean and in Italy. The southerly winds coming, on the contrary, from the polar regions, are cold and dry. They blow constantly towards the equator; and as they disperse the vapours and drive them to the Andes, it seldom rains in Chili while they continue to blow. But these clouds, thus driven by the south winds towards the Andes, uniting with those which come from the north, occasion very heavy rains in all the provinces to the east of the mountains. It seldom rains in the northern provinces of Chili; but in the southern provinces rain is more frequent; and near the sea dreadful storms occasionally arise. In the islands, also, the rains are very frequent even in summer.

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Thunder is scarcely ever heard even in summer in those parts of the country which are at a distance from the Andes. In the maritime provinces, snow is never seen. In those nearer the Andes, it falls once perhaps in the course of five years; but it seldom remains on the ground for a single day. In the month of August, also, a white frost is sometimes seen, accompanied by a slight degree of cold. But this coldness does not continue above two or three hours after sunrise; from which time the temperature of the atmosphere is like that of a fine day in spring. In the Andes, on the contrary, snow storms are frequent, and snow falls in such quantities from April to November, that the ground is covered with it during all that time to a great depth, so that the mountains are quite impassable for the greatest part of the year. Abundant dews fall throughout most parts of Chili, which in a great measure supply the want of rains; and fogs are common on the coast, although they are generally dissipated as the day advances.

Rivers.

Chili is watered by about 123 rivers, which have their sources in the Andes, and 52 of which communicate with the sea. Of these the principal are the Maule, in the province of the same name; the Biobio, two miles in breadth; the Cauten; the Totten; the Valdivia, in the country of Arauco; the Chaivin; the Rio-bueno, and the Sinfondo, which discharges itself into the archipelago of Chiloe. The two most remarkable lakes are the Laquen, which the Spaniards call Villa-rica, which is 72 miles in circumference, and the Nahuelguapi, which is 80 miles in circumference.

Volcanoes and Earthquakes.

Owing to the great quantity of sulphureous, nitrous, and bituminous substances contained in its soil, Chili is subject to volcanic eruptions and earthquakes. Among the Chilian Andes there are fourteen volcanoes in a constant state of eruption, and a still greater number from which smoke is occasionally discharged. These, however, being in general situated nearly in the middle of that range of mountains, their destructive effects are confined within certain limits, and seldom extend to the plains. There are only two volcanoes in the whole of the country not included in the district of the Andes, the principal of which is the great volcano of Villarica, near the lake of the same name. This volcano, the summit of which rises into the region of perpetual snow, is in a constant state of eruption, and may be seen at the distance of 150 miles. Earthquakes are common in Chili. The inhabitants calculate upon three or four annually. They are, however, in general, very slight, and little attention is paid to them. Within a period of 244 years, from the arrival of the Spaniards to the year 1782, only five violent shocks have been experienced; the first in the year 1520; the second in the year 1647; the third in 1657; the fourth in 1730, when the sea was impelled against the city of Conception, and overthrew its walls; and the fifth in 1751, during which that city was completely overwhelmed by the ocean. At present the shocks are less violent than formerly, and are generally confined to horizontal or oscillatory motions. The inhabitants are also forewarned of these convulsions by the hollow noise which precedes them, and they have built both their houses and their cities upon such a plan as to afford them an easy and safe retreat from the effects of this calamity. In the cities, the streets are so broad that the inhabitants are always safe in the middle of them, in whatever direction the houses may happen to fall; and all those which belong to the richer classes have spacious courts and gardens attached to them, which serve as a place of retreat in case of danger. These precautions are quite sufficient to prevent any useless alarms, more especially as the earthquakes which happen in this country have never been attended with any considerable sinking of the earth, or with the falling of buildings. It is supposed that the volcanoes in the Andes are so many outlets, which, by affording vents to the subterraneous fluid, render its action less violent, and its effects consequently less destructive.

Productions.

The soil of Chili is remarkably productive, and the country, in its uncultivated parts, every where presents the most profuse and vigorous vegetation. The plains, the valleys, and the mountains, are covered with a variety of beautiful trees, many of which preserve their verdure throughout the whole year, and each season produces its peculiar succession of vegetables in the greatest perfection. Different travellers have given the most extraordinary accounts as to the fertility of the soil. In Frazier's *Voyage* it is mentioned, that it yields from sixty to eighty, and even a hundred fold. Others mention, that the crop is considered poor if it does not exceed the proportion of one hundred to one, while there are some who state the increase at three hundred to one. Molina mentions, that he has himself witnessed instances of lands producing one hundred and twenty, and even one hundred and sixty for one. These, however, he states to be extraordinary instances. The maritime districts are less fertile than the middle districts, and these again yield in point of fertility to the rich valleys of the Andes.

The common produce in the middle districts is stated by Molina to be from sixty to seventy for one, and in the maritime districts to be from forty to fifty. The soil of Chili is extremely favourable to the production of maize, wheat, barley, and rye. Hemp and flax also grow extremely well; but as the exportation of this produce was rigorously prohibited under the regime of the mother country, the inhabitants were accustomed to raise no more of these articles than what was sufficient for their own domestic consumption. In the northern provinces many of the tropical productions grow to great perfection. The principal of these are the sugar-cane, the cotton plant, the banana, the pine apple, the sweet potatoe, jalap, mechoacan, and others of less importance. Many of the plants and fruits which are found in the country are common both to Chili and to Europe, and others that are carefully cultivated in Europe, grow naturally in this more favoured country. Chili has a variety of plants peculiar to it, of which about 3000 different species were collected by Molina. Among these were numerous flowers remarkable for their beauty and fragrance, and which, when they are in bloom, give the fields the appearance of so many parterres. Medicinal, dyeing, and aromatic plants, are also produced in great abundance. The different fruit trees, garden herbs, and flowers, which

 have been imported by the Spaniards from Europe, grow many of them even to greater perfection in Chili than in the countries to which they are indigenous. The vine produces in great abundance, and the soil appears to be peculiarly well adapted to it, as the thickets are filled with wild vines, from which the inhabitants contrive to obtain wine of a very good quality. But the cultivated vines are in the highest degree excellent, and the wine obtained from them is the best in Chili. It is in general red, and, in point of flavour, is not inferior to any European wine. The Muscadel wine, according to Ulloa, is of as good a quality as that which is made in Spain. The European fruit trees thrive equally well. In the southern provinces are forests of apple and quince trees from three to four leagues in extent, which produce fruit of excellent quality. The peaches amount to fourteen species, some of which weigh more than sixteen ounces, and the tree bears fruit twice in the year. Pears and cherries also produce two crops annually, but the latter growth rarely comes to great maturity. Oranges, lemons, and citrons, grow every where in the open fields, and besides the common lemon, a small species is produced, the fruit of which is about the size of a walnut, and very juicy. The olive, the first plant of which was carried from Andalusia to Peru in 1560, grows to great perfection; and Molina relates, that in the vicinity of St Iago he has seen olive trees three feet in diameter, and of a proportional height.

Mines. Chili is rich in metallic wealth. It produces all the known kinds of the semimetals. These, however, are all neglected, with the exception of quicksilver, which it is necessary to procure for the refining of the precious metals. The two richest mines of this substance are in the provinces of Coquimbo and Copiapo, which might be rendered very productive if they were permitted to be worked. But the selling of quicksilver being a royal monopoly, the digging of it was rigorously prohibited, while Chili remained a colonial dependency of Spain. But if the present struggle for independence in which Chili, along with the other provinces of South America, is engaged in opposition to the mother country, shall terminate successfully, those arbitrary and absurd restrictions will naturally be superseded by a wiser and more equitable system.

Metals abound in all parts of the country. Lead is found of a good quality; and it is obtained in all the silver mines. All the lead mines also contain silver and gold; but in too small a quantity to excite the attention of the miners. The provinces of Coquimbo, Copiapo, Aconcagua, and Huilquilemu, contain very rich mines of iron; and the sand on different parts of the sea-shore, and on the borders of brooks and rivers, is replete with particles of this metal. In the true spirit of that tyrannical dominion which the Spanish government has always exercised over its colonies, those mines were prohibited from being worked, in order to favour the trade of the mother country, from which all the iron used in the colonies was imported, and thus the industry and resources of the immense regions of the new world were condemned to lie neglected and unproductive, under the pernicious thraldom of this absurd monopoly. In the course, however, of the last war between the mother country and Great Britain, this metal rose to such an exorbitant price, that the native iron was secretly wrought; and it proved to be of an excellent quality. There are also abundant mines of tin, which is usually found in sandy mountains, under the appearance of black stones, very brittle and heavy. These mines are equally neglected with those of iron and lead.

From the conquest of the country to the present time, the mines of gold, silver, and copper, have occupied almost the undivided attention of the Spaniards. The copper mines are not confined to any particular district; but are found in all parts of the country. The richest mines are situated between the twenty-fourth and thirty-sixth degrees of latitude. The ore obtained from them is of every various quality, and it usually contains a proportion of gold which varies from one-tenth to one-third. Some of the ores which are rich in metal, are considered of no value from the expence of refining them; those generally wrought are the grey, or bell-metal ore, and the malleable copper. The grey ore, or bell-metal, is usually mineralized with arsenic and sulphur, and contains a small mixture of tin. From this mixture, and its grey colour, which it retains even after it is melted and refined, Molina considers it as a species of native bronze, which metal it also resembles in its brittleness. Its specific gravity, when artificially combined, is however greater than that of any one of the metals of which it is composed. The malleable copper, which abounds in different provinces, possesses all the usual properties of that metal, and is found mineralized with a small portion of sulphur, which the simple process of roasting is sufficient to expel, and to render the metal fit for use. The miners, however, refine it in the usual manner, from a notion that it improves the metal in brightness. The malleable copper is always found combined with gold, and veins of pure gold are frequently found in the deepest copper mines. Between the cities of Coquimbo and Copiapo, the number of copper mines which are worked amount to one thousand; many more have been opened. But those only are worked, of which the ore is so rich as to yield half its weight in refined copper. The most celebrated copper mine in Chili was that of Payen, the working of which was relinquished in consequence of the hostility of the native tribes who inhabited the district. Pieces of pure copper, from 50 to 100 weight, were frequently found in this mine. Another equally rich mine has since been discovered at Curico. The ore consists of gold and copper in equal proportions, and has an uncommonly brilliant appearance from the particles of this precious metal with which it is filled. The quantity of copper annually extracted from the mines of Chili, cannot be ascertained with any exactness. It is conjectured by Molina, that about 100,000 quintals (of 1600 ounces each) are annually imported to Spain. Great quantities are also sent to Buenos Ayres, and about 30,000 quintals are annually sent to Peru, besides what is used for domestic purposes.

The silver mines of Chili are found in the highest and coldest parts of the Andes; and various mines, though rich in ore, have, on this account, been abandoned from the difficulty and expence of work-

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ing them. The richest are those of St Iago, Aconcagua, Coquimbo, and Copiapo. In these the silver is frequently found pure; it is also found in various sorts of ores mineralized with sulphur and arsenic. The mine of Uspallata, situated in the 33d degree of south latitude, and so named from the plain of that name, is the most productive. There are three species of ores yielded by this mine which have been found, from assays made at Lima, to yield 200, 50, and 14 marks *per* caxon, which is equal to about 1 in 38, 1 in 154, and 1 in 548.

Gold is, of all the metals, most abundant in Chili, and, in some parts of the country, there is scarcely a mountain which does not contain it in a greater or less degree. It is found also in the sands of the plains, and is washed down from the mountains by the brooks and rivers. In the southern provinces, between the river Biobio and the archipelago of Chiloe, several productive mines were formerly discovered. But since the expulsion of the Spaniards from this quarter by the Araucanians, the warlike inhabitants of the country, these mines have been in their possession, and they have prohibited them from being opened. The most important mines which are at present wrought, are those of Copiapo, Guase, Coquimbo, Petorca, Ligua, Tiltil, Putaendo, Caen, Alhue, Chibato, and Huilli-patagua. All these, with the exception of the three last, have been wrought ever since the conquest of the country by the Spaniards, and have been found very productive. The substances in which gold is found are very variable, and there is no kind of stone or earth which may not be said occasionally to serve as a matrix for this precious metal. It is most frequently found in a very brittle red clay stone, and is to be seen in small grains or brilliant spangles under singular forms, or in irregular masses that may be cut with a chisel. The mines are worked either with the pick-axe or by explosion, according to circumstances. The rock in which the ore is found being then reduced to powder by a mill of a simple construction, the gold is extracted by the common process of amalgamation with mercury. Gold is also procured by the washing of the auriferous sands. But this method is only practised by the poorer classes, who cannot afford the expences of regular mining. The quantity of the gold annually found in Chili, which pays the royal duty of one-fifth, is estimated by Molina to amount in value to four millions of dollars. A million and a half is coined at the mint of St Iago; the remainder is exported in bullion, or is used in the country for plate and jewellery. There is besides a considerable quantity smuggled.

imals.

Chili is not so abundant in animals as some of the other countries of America. The indigenous quadrupeds hitherto discovered amount to 36 species; but it is the opinion of Molina, that, in the unexplored and desert regions of the Andes, many others exist which are hitherto undiscovered, or imperfectly known. Of the species peculiar to Chili, the most remarkable is the vicunna, or the guanaco, sometimes called the American camel, from its resemblance to that animal in shape; although it differs from it in another essential quality, namely, that, while the camel is fitted by its constitution to live in the most parched and sultry deserts, the vicunna is most vigorous and thriving in the inclement regions of the higher Andes, amid ice and everlasting snow. The lama, or Peruvian sheep, is also found in the Andes of Chili. The other animals are the wild goat, the dog, the fox, and the pagi, or lion, which animal it resembles in its size and roaring, though it is destitute of mane. All the European animals have been carried to Chili, where they have multiplied exceedingly, and some of them have even increased in size. The birds are very numerous, amounting, those that belong to the land, to 135 species, while it is impossible to enumerate all the different species of sea-birds. There are but few reptiles, and the insects are less numerous than in some of the southern countries of Europe. The coasts of Chili abound with various kinds of excellent fish, of which the different species are calculated to amount to 76, most of which differ from those found in the northern hemisphere, and appear to be peculiar to that sea. The bays, harbours, and in a particular manner the mouths of the large rivers, swarm with them, and in many places they are caught with very little trouble. The fresh waters also abound in fish, especially those which are beyond the 34th degree of south latitude.

Population.

The population of Chili is composed of Europeans, Creoles, Indians, Negroes, and Mestizoes. Of these the Creoles form the most numerous class. There exist no data for a general enumeration of the population; but it is certain that the country is very thinly stocked with inhabitants, in proportion to its fertility.

Recent History.

The domestic tranquillity of Chili has been seldom disturbed since its original conquest, except by the wars continually waged between the Spaniards and the tribes of Indian natives, many of whom still continue to enjoy their barbarous independence, and to defy the utmost efforts of the Spanish arms. But about the year 1810, when the French had nearly effected the conquest of the mother country, the Chilian, along with the other provinces of Spanish America, began to take measures for establishing their independence. At first affairs seemed to wear the appearance of unanimity and peace. The authority of the mother country was quietly superseded by the aristocracy of the colony, and the government passed into the hands of the great Creole families. Since this period, Chili appears to have been subjected by the royal armies; but lately it has been restored to independence by a detachment from the army of Buenos Ayres, under San Martin, who, having defeated the royal troops in several engagements, has made himself master of all the most important places of the country. The accounts hitherto received in Europe of these events are too partial and contradictory to enable as to enter at present into any detailed or connected narrative of them. But an opportunity will occur in the general article of South America, for a full account of the great revolution which has taken place in this continent.

See *History of Chili*, by Don Ignatius Molina, 1809.—*Travels from Buenos Ayres by Potosi to Lima*, by A. T. Helms, 1807.—*Edinburgh Review*, Vol. XIX.

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CHINA.

China.

If the embassy of the Earl Macartney to the Court of Pekin failed in its immediate object, which was just about as reasonable as if the Emperor of China had sent to demand from us the cession of the Isle of Wight, it succeeded at least in throwing a more clear and distinct light on the nature of the government, the laws, language, and literature, of one of the most ancient, and most extensive, and, beyond comparison, the most populous nation of the world. It was the means of obtaining a nearer insight into the manners of the people, and of forming a more correct estimate of their moral character, than had hitherto been given in the prejudiced accounts of the Romish Missionaries. But the most important acquisition which resulted from this embassy, in a literary point of view, was, the complete developement of the extraordinary language of the Chinese, which the Jesuits had invariably represented as of so obscure and mysterious a nature, that the whole period of human existence was too short to acquire even a competent knowledge of it; whereas we now know that a moderate degree of application for two or three years, with the assistance of a Chinese, will enable the student to write it with ease, to read and translate their most obscure books, and to transact every kind of business, commercial or political; and that this knowledge has opened up a vast fund of literature which, in Europe, was hardly suspected to exist. To Sir George Staunton, in the first place, to Dr Marshman and his son, at Serampore, to Mr Morrison, a Missionary at Canton, and to Mr Davis, a promising youth in the East India Company's Factory at that port, we are more indebted for a true and distinct state of the laws, the language, the institutions, and literature of China, than to all the voluminous writings of the Jesuits, which, however curious and valuable in many details, are crowded with errors and exaggerations. These pious men, under the influence of bigotry and prejudice, have left untouched, or misrepresented, or wrapt up in mystery, many subjects of considerable interest in a religious, political, and moral point of view; nor are they without excuse. They entered China at a time when the comforts and conveniences of life were but little known in Europe, and still less to them, whose knowledge extended not beyond the boundary wall of their respective monasteries; they were flattered, also, by the reception they met with from the sovereign of so vast and powerful an empire—circumstances which naturally disposed them to exaggerate the moral and political virtues of the people among whom they had voluntarily domiciliated themselves for life. There was enough, however, to excite their admiration. A country swarming with a population, which for ages had kept itself wholly unmixed with the rest of the world,—whose language, laws, and institutions, had no analogy with those of any known nation, and had suffered no change—to whom the art of printing was known and freely practised, without licence or previous restraint, for centuries before the dark ages overshadowed Europe; who were clothed in silk and cotton garments, when Europeans had only skins to cover them with; and who were acquainted with most of the useful arts and manufactures, at a period long antecedent to the Christian era. Such a people, inferior as they now may be in science and civil liberty to some of the nations of Europe, could not be regarded with indifference, but had then in particular, as they still continue to have, powerful claims to the attention of mankind. By combining and comparing these early accounts with more recent materials, and by the help of some small personal information, we may be enabled to make some additions to, as well as to correct some inaccuracies in, the Article on CHINA in the body of the *Encyclopædia*.

The conterminous empires of Russia and China occupy between them about one-fifth part of the habitable globe, in pretty nearly equal portions; but the population of the latter is about four times greater than that of the former, even after including its recent addition of ten millions of Poles. We can easily trace the boundaries and mark the extreme limits of these two great empires, by parallels of latitude and meridional lines of longitude; but when we come to reduce them to square miles, or speak of their contents in acres, the mind is bewildered in the magnitude of the numbers required to express them, and forms but an indistinct idea of their superficial extent. For this reason we shall content ourselves by merely tracing the boundary lines.

Boundaries.

The frontier of China, on the side of Russia, including every part of Tartary under its immediate protection, and from which it derives a tribute, is as under: Commencing at the north-eastern extremity, where the Uda falls into the sea of Otchotsk, in the 55th parallel of northern latitude, it stretches west, and W. S. W. along the limits of the Tungousi Tartars, the Duourian Mountains, along the Kerlon, which divides it from the Russian province of Nertchinsk, till it meets the 50th parallel. It then continues along that parallel from 117° to 70° of E. longitude, separated from Tobolsk and Irchutsk by the Sawansk, the Altai, and the Bercha mountains. On this line, and about the 106th merdian, on the river Selinga, are situated the two frontier trading towns of Kiackta and Mai-mai-tchin, the only two points in the long conterminous line of boundary where Russians and Chinese have any communication. From hence, descending south along the Kirghis Tartars, Western Toorkistaun, and Little Thibet, it is terminated in this direction by the Hindoo Coosh; and turning to the S. E. along the Himmaleh Mountains, Bootan, Assam, the Burman Empire, and Tunquin, it again skirts the sea in the parallel of 21° as far to the eastward as 123° (in-

cluding Corea, to 130°), and near the Uda, from whence we set out, to 143° of E. longitude. Yet in all this extent of frontier, which cannot be less than 10,000 geographical miles, the Chinese territory has hitherto preserved itself so invulnerable, and even inaccessible to foreigners, that not a Russian, a Turcoman, an Afghaun, a Hindoo, Burman, or Tunquinese, by land, nor an European nor an American, among the numbers that annually proceed to Canton for the purposes of trade, have at any time been able to transgress any part of this most extensive boundary, without the knowledge and permission of its vigilant and jealous government; aided, however, by a moral barrier, of itself perhaps insuperable,—the impossibility of communication, from the total ignorance which prevails, from the highest to the lowest of the people, of every language but their own, and the unaccountable ignorance of other nations of *their* language. A singular instance may here be mentioned of the inviolability of the frontier, notwithstanding the perseverance of the individual who attempted it, from the unwearied vigilance of the government. Mr Manning, an English gentleman of property and education, went to Canton many years ago, with the view of proceeding into the interior of China, and of domesticating himself for some time with the people. On his arrival there he adopted the Chinese dress, suffered his beard to grow, and sedulously applied himself to the study of the language, both written and spoken. When the time approached that his appearance, manners, and language were considered to be sufficiently Chinese to escape detection, it was communicated to him, by a sort of demi-official message, that his intentions were known, and that it would be in vain for him to make the attempt, as measures had been taken to make it impossible for him to enter the Chinese territories beyond the limits of the English factory. He alleged that his views were innocent, that he was simply an individual, urged solely by curiosity and a desire to mix among the people, and to witness the happy condition of this far-famed nation, wholly unconnected with any political, commercial, or religious views,—and he particularly urged, that he was no missionary of any kind, as those of that character had of late given uneasiness to the government,—but he urged his suit in vain. He next tried Cochin-China, but with no better success; the same kind of political jealousy prevailing in that country as in China. Determined, however, not to be thwarted in his object, he proceeded to Calcutta, travelled to the northern frontier of Bengal, found means to penetrate through Bootan to Lassa in Thibet, and was on the point of realizing his long deferred hope by a journey along the Tartar frontier to the capital of China, when he was detected by the Chinese authorities, and ordered immediately to quit the country—so utterly impossible is it to deceive this watchful government. With regard to their own people, the laws are strict, and remarkably severe against any one who shall secretly or fraudulently pass the barrier; and if any individual communicate with foreign nations beyond the boundaries, the penalty is death by strangulation.

Inviolability of the Frontier.

This interdiction of intercourse with a people who have nothing in common with the rest of the world, will account for the total ignorance that so long prevailed, and the little knowledge we yet possess, respecting this singular and original people; for that they are an original and unmixed race we conceive no reasonable doubt can be entertained, though a different hypothesis has been held by learned and ingenious men. By De Guignes and Fréret, arguing from the communications of the Jesuits, they were supposed to be derived from a colony of Egyptians; by the earlier Jesuits they were set down as a tribe of the Jews; and by Sir William Jones as the descendants of the Cshantrya or Military Caste of Hindoos, called Chinas, "who," say the pundits, "abandoned the ordinances of the Veda, and lived in a state of degradation." With submission to such high authorities, we should as soon think of deriving the trunk of a tree from its branches, as the people of China from any of these. That they are not Egyptians, the ingenious Pauw has most clearly and satisfactorily demonstrated, by proving that, in no one iota, does there, or ever did there, exist one single resemblance. As little similarity is there between them and the Hindoos; no two people, indeed, could possibly differ more than they do in their physical and moral character, in their language, and in their political and religious institutions. The colour of the Hindoo is ebon black or a deep bronze; that of a Chinese a sickly white, or pale yellow, like that of a faded leaf, or the root of rhubarb;—the features of a Hindoo are regular and placid; those of a Chinese wild, irregular, constant only in the oblique and elongated eye, and the broad root of the nose;—the Hindoos are slaves and martyrs to religious ordinances; the Chinese have superstitions enough, but, strictly speaking, no religious prejudices;—the Hindoos are divided into castes; the Chinese know of no such division;—the historical records of China go far beyond the time that these supposed Chinas, of Sir William Jones, peopled the country; the Hindoos have not a page of history;—the language of Hindostan is alphabetic; that of China a transition from the hieroglyphic to the symbolic; and there is not the slightest analogy in the colloquial languages of the two countries. But Sir William Jones had a theory to support, which made him overlook many inconsistencies; and he had no knowledge of the Chinese language. The name of Chinas seems to have caught him, a name, however, utterly unknown to the Chinese themselves. The madman, who, in the third century before Christ, is accused of burning all their books, but who conquered the revolted provinces and reunited them to the empire, endeavoured to give to China the name of his own dynasty, *Tsin*, which might have been known to the Hindoos, and, through them, to the Arabs, from whom Europeans had their *Sina* and China; but this dynasty, if we take Sir William Jones's dates, reigned a full thousand years subsequent to the supposed emigration of the Chinas. The most ancient name for China, which is still in use, is *Tien-sha, under heaven*, or inferior only to heaven, but the most common appellation is *Tchung-quo*, the middle kingdom: and here it may be pro-

Erroneous Opinions concerning the Origin of the Chinese.

per to observe, that this name is not given, as the French missionaries would lead us to suppose, from a notion, among this people, that China is placed on the middle of the earth's square surface, but from the circumstance of the Emperor Tching-whang having fixed his court at Lo-yang, in the province of Ho-nan, when he gave to this capital the name of *Chung-quo*, the middle of the kingdom, which, in fact, is nearly the truth, and this name was afterwards transferred to the whole empire.

Dr Marshman has set the question, as to any similarity between the Sanscrit and Chinese languages, completely at rest. The priests of Budh, who were permitted to enter China in the first century of the Christian era, endeavoured, with their religion, to introduce the Sanscrit alphabet, or series of sounds represented by the Devanagari character, and this series being placed at the head of Cang-he's Dictionary, induced Dr Marshman to suppose, that there might be some connection between the Chinese and the Sanscrit languages; had he, however, read the preface to that dictionary, he would have seen, that the compilers announce it as a system brought from the West, which the learned of China could never be prevailed on to adopt. This Hindoo series of alphabetic sounds did not, however, mislead him; he was fully aware that a pure, unchangeable, monosyllabic language, could not arise out of a polysyllabic one; that a language which admitted of no change from its original monosyllabic root, but retained it in its primitive form, whether employed as a noun, a verb, or a participle, could not have been derived from another language whose dhatoos or roots, by a complicated mechanism, assumed a hundred different shapes; nay, whose inflections, in some instances, are so numerous, as to produce more than a thousand modifications of an idea from one radical word. Added to all which, when he reflected that there were in the Sanscrit alphabet four or five sounds which the organs of a Chinese could not by any possibility enumerate, he found it utterly incompatible to associate the two languages together, and was confirmed in his idea by the test of facts. He took the Ramayuna, which is supposed to be the most ancient poetry in the Sanscrit language, and the *Shee-king* of the Chinese; in ten pages of the former, containing four hundred and fifty-nine words, he found only thirteen monosyllables, and of these thirteen, seven do not occur in the *Shee*, nor are any two of them used to express the same idea in both languages. He next took four pages of the Mahabharu, in the Bengalee dialect, containing two hundred and sixty-five words, in which he found only seven monosyllables, and of these *three* only were Chinese.

Proceeding in the same manner, he proves, what was scarcely necessary, that there exists not the most distant resemblance between the Chinese and the Hebrew languages. In examining the speech of Judah to Joseph, in the 44th chapter of Genesis, he finds it to contain two hundred and six words, in which there occur sixteen monosyllables, but of these seven only are Chinese words. In Abraham's intercession for Sodom, out of two hundred and thirty words, ten only are monosyllables, and of these four are Chinese. Again, in the maledictory prophecy of Noah, relative to his grandson Canaan, in twenty-six words there is but one monosyllable. It would be most absurd, therefore, to conclude, that the Chinese derived their language from the Hebrew, when one word only occurs out of twenty-nine, as in the first example,—one out of fifty, as in the second,—or one in twenty-six, as in the third; and he thinks it more rational to infer, that, as it is neither derived from the Sanscrit nor the Hebrew, it is an original language, invented by themselves. Neither is there any resemblance to be found in the manners, customs, physical character, or religious creeds of the two people. There are, in fact, a colony of Jews in China, whose entrance can be traced beyond the Christian era; who use the Hebrew language; who abstain from swine's flesh, the great article of Chinese food; use circumcision, and celebrate the Passover, neither of which the Chinese know any thing about; and it may, therefore, fairly be concluded, that they are neither Jews, Hindoos, nor Egyptians, but an original people, who have kept themselves more unmixed with other nations than any people existing on the face of the earth. (Barrow's *Travels in China*. Marshman's *Clavis Sinica*.)

Probable Origin.

Pauw, and some other writers, are of opinion, that they proceeded originally from the heights of Tartary. It is, in fact, obvious enough, that the Tartars and Chinese are one and the same race; and the only question seems to be, whether the latter, guided by the mountain-streams, descended from the bleak and barren elevations of Tartary, which, bulging out of the general surface of the earth, have been compared with the boss of a shield, to the fertile plains and temperate climate of China? or, whether the former are swarms sent off by an over-abundant population, and driven into the mountains? The former supposition will be regarded, perhaps, as the more probable of the two. In all the institutions which the change from a pastoral to an agricultural state would necessarily require, the ancient manners and customs of the Hyperborean Scythians, as described by Herodotus, are still discernible among the Chinese. A Chinese city is nothing more than a Tartar camp, surrounded by mounds of earth, to preserve themselves and cattle from the depredations of neighbouring tribes, and nocturnal attacks of wolves and other wild beasts; and a Chinese habitation, the Tartar tent, with its sweeping roof supported by poles, excepting that the Chinese have cased their walls with brick, and tiled the roofs of their houses. When the famous barbarian Gengis-Khan made an irruption into the fertile plains of China, and took possession of a Chinese city, his soldiers immediately set about pulling down the four walls of the houses, leaving the overhanging roofs supported on the wooden columns, by which they were converted into excellent tents for themselves and horses. Yet such is the facility with which Chinese and Tartars amalgamate, that although this celebrated barbarian could neither read nor write any language, he listened to the advice of the conquered,—became sensible of the change of situation in which he found him-

self,—did every thing he could to repair the errors he had committed,—and both he and his successors left good names behind them in the annals of the country. In like manner the present Mantchoo Tartars, who lived in tents, and subsisted on their cattle and by hunting, immediately accommodated themselves to the manners, the customs, and the institutions of China, preserving nothing of their own, not even their religion, and scarcely a vestige of ancient superstitions that do not coincide with those of the Chinese,—one of the most singular of which is, their agreement in the birth of man and of the serpent-woman, and the universal use and estimation of the ancient Scythian emblem of the dragon. Next to the Chinese, the Turks seem to have preserved most of the character and customs of the ancient Scythians from whence they sprung, and the Turks are Tartars. Some German author has pointed out a similarity between the Turks and Chinese in seventeen different customs; he might have extended the parallel to more than twice that number.—(*Recherches sur les Chinois, &c.* par M. de Pauw.)

Antiquity and History.

It has long been objected in Europe against the authenticity of the early part of Chinese history, that it abounds with absurd fictions and irreconcileable contradictions; and that it sets up a chronology and cosmogony at variance with the sacred writings, and the generally received opinions of mankind. This, however, is not the fact with regard to Chinese history in its pure and original state, divested of the reveries of Fo or Budh, which the priests of this sect imported with their religion, and found means to propagate among the vulgar. The Hindoo periods of the creation and destruction of the universe,—the miraculous conceptions,—and all the absurd stories of gods, demi-gods, and heroes, are scouted by the learned of China. The period they assign for the commencement of their civilization, is perfectly consistent with the time when, according to holy writ, the great catastrophe befel the earth; and though they are unable to establish the truth of the early part of it by any concurring contemporaneous histories of other countries, yet neither can any extraneous authority be produced to contradict theirs; the probability, therefore, of the truth or falsehood, must rest on the internal evidence of their own history, and the manner in which that history has been compiled, preserved, and handed down to posterity.

We may take it for granted, that when the Emperor Kaung-hee summoned to Pekin the most learned men of the empire, for the purpose of translating into the Mantchoo language an abridged history of China, from the earliest times, those annals only were consulted which were considered most authentic, namely, those which are compiled and published by the college of *Han-lin.* Pere Mailla was one of those missionaries who viewed the Chinese through the eye of prejudice less than most of the Jesuits. He was employed by the Emperor in making a survey of the empire, which cost him and his colleagues the labour of ten years; he passed forty-five years of his life in the country, and generally about the court, during which time he made himself perfectly acquainted with the Mantchoo and the Chinese languages. When, therefore, Kaung-hee undertook the laudable design of giving to his Mantchoo subjects an authenticated history of China in their own language, Pere Mailla conceived the idea of proceeding *pari passu* with a translation of the same work into French; and having lived to complete this Herculean labour, it was published at Paris, after many difficulties and delays, by the Abbé Grozier, in fourteen large quarto volumes, under the title of "*Histoire Generale de la Chine.*"

The history of China commences, in fact, at a period not much more than 3000 years before the birth of Christ, by describing the little horde, from whence the Chinese had their origin, to be in as barbarous and savage a state as can well be imagined; roving among the forests of *Shen-see*, just at the foot of the Tartar mountains,—without houses,—without any clothing but the skins of animals,—without fire to dress their victuals,—subsisting on the spoils of the chace, on roots and insects. Their chief, of the name of *Yoo-tsou-she*, induced them to settle on this spot, and they made themselves huts of the boughs of trees. Under the next chief, *Swee-gin-shee*, the grand discovery of fire was effected, by the accidental friction of two pieces of dry wood. He taught the people to look up to *Tien*, the great creating, preserving, and destroying power; and he invented a method of registering time and events, by making certain knots on thongs or cords twisted out of the bark of trees. Next to him followed *Fo-hee*, who separated the people into classes or tribes, giving to each a particular name; discovered iron; appointed certain days to show their gratitude to heaven, by offering the first fruits of the earth; and invented the *Ye-king* or *Koua*, which superseded the knotted cords. Fo-hee reigned 115 years, and his tomb is shown at Tchin-choo, in the province of Shen-see, at this day. His successor, *Chin-nong*, invented the plough, and from that moment the civilization of China proceeds by rapid but progressive steps.

As the early history of every ancient people is more or less vitiated by fable, we ought not to be more fastidious or less indulgent towards the marvellous in that of China, than we are towards Egyptian, Greek, or Roman history. The main facts may be true, though the details are incorrect; and though the accidental discovery of fire may not have happened under Swee-gin-shee, yet it probably was first communicated by the friction of two sticks, which, at this day, is a common method among almost all savages of producing fire. Nor is it perhaps strictly correct that Fo-hee made the accidental discovery of iron, by having burnt a quantity of wood on a brown earth, any more than that the Phenicians discovered the mode of making glass by burning green wood on sand; yet there is nothing improbable, neither in the one nor the other, that these two processes first led to the discovery of both. And if it be objected against the history, that the reign of a hundred and fifteen years exceeds the usual period of human existence, it should be recollected, at the same time, that such an instance is as nothing, when compared with those contemporaneous ones recorded in biblical history. Thus also considerable allowances are to be deducted from the scientific discoveries of Chin-nong in botany, when we read of

his having in one day discovered no less than seventy different species of plants that were of a poisonous nature, and seventy others that were antidotes against their baneful effects.

The next sovereign, Hoang-tee, was an usurper; but during his reign the Chinese are stated to have made a very rapid progress in the arts and conveniences of civilized life; and to his lady, See-ling-shee, is ascribed the honour of having first observed the silk produced by the worms, of unravelling their coccoons, and working the fine filaments into a web of cloth. The tomb of Hoang-tee is also kept up to this day in the province of Shen-see.

From these few recorded facts, out of a multitude stated by Chinese historians, we think it may be inferred, that at a very distant period, and at the earliest dawn of civilization, a small horde of Tartars, descending from their elevated regions, seated themselves on the plains of Shen-see, at the foot of the mountains; and, under the guidance of a succession of intelligent chiefs, changed the pastoral and venatorial life for one more stationary, and at length became cultivators of the soil, and spread themselves over the fine fertile regions, now known by the name of China. (*Hist. Gen. de la Chine*, par P. Mailla.)

Authenticity of their History examined.

Some doubts have been entertained with regard to the authenticity of that part of Chinese history which relates to the reign of the three first sovereigns, *Fo-he*, *Chin-nong*, and *Hoang-tee*, which is supposed to have been contained in a book called the *San-fen;* and of the five following reigns, ending with the joint government of *Yao* and *Chun*, as detailed in another work named the *Ou-tien*. Of the first of these works the Chinese avow that nothing is known; and all that remained of the second was an imperfect fragment preserved by being inserted at the head of one of their most ancient and most valued books, called the *Shoo-King*, of which we have a translation, or rather a bad paraphrase, by Pere Gaubil. This fragment relates chiefly to the reign of *Yao* and *Chun*. The rest of the *Shoo-king* contains an abridged history of the empire from the joint reign of these two sovereigns, down to the time of Confucius,—being a compilation by this celebrated sage. The authenticity of the *Shoo-king* must, however, depend on two circumstances; first, whether it is the same that was composed by Confucius; and, secondly, whether the materials which this sage possessed were authentic. If he really had copies of the *San-fen* and *Ou-tien*, the *Shoo-king* may fairly be classed with the history of Herodotus, with whom Confucius was contemporary,—the Chinese historian having the additional advantage of previous written records. But, admitting this to have been the case, there is still an awkward and suspicious chasm in the history of China, the cause of which draws largely on our faith. The Emperor Che-whang-tee, of the dynasty of *Tsin*, after reducing, as we before observed, the refractory provinces, conceived the mad scheme of destroying all the writings of the empire, under the idea of commencing a new set of annals with his own reign, in order that posterity might consider him as the founder of the empire. Some sixty years after this barbarous decree had been carried into execution, his successor, desirous as far as might be possible to repair the injury, held out great rewards to those who could produce any part of the annals of the empire, more especially the hundred chapters of the *Shoo-king*. After some time a copy of the *Shoo-king* was procured in this manner. All ancient writings, and those of Confucius in particular, were comprised in short sentences, forming a kind of poetry, not unlike the Proverbs of Solomon; and they were in the memory of most persons then, as they are now, who had any pretensions to literature; but sixty years having been suffered to elapse before any encouragement was held forth for the revival of letters, most of those who had known the *Shoo-king* were either dead, or so old as to have lost the recollection of it. At length, however, a man named Foo-seng, of the age of ninety and upwards, was discovered, who, in earlier life, could repeat the whole *Shoo-king* by heart. To this man the historiographers of the empire were sent: but his articulation was so imperfect, and he was unable to write, that the parts of it which he recollected could only be obtained through the medium of his daughter, who, having received the words from her father, repeated them to the historians. In this way they proceeded, until twenty-nine of the books or sections of the *Shoo-king* had been committed to writing, which Foo-seng had comprehended in twenty-five; but here they were compelled to stop, the infirmities of Foo-seng not allowing him to proceed. A document thus obtained, did not pass for genuine among the learned; yet all were eager to procure copies of it, to compare such passages as each might recollect to have heard their fathers repeat. The early annals of China, however, do not rest solely on this record. Half a century after this, a prince of Loo, in pulling down an old building (some say the house in which Confucius lived), to erect on its site a temple in honour of that philosopher, discovered in one of the walls an imperfect copy of the *Shoo-king*, with two other works of Confucius. They were much devoured by the worms, and written in a character which had gone out of use. The learned men were assembled to collate this newly discovered copy with that taken from Foo-seng's recollection, and it is said that they did not materially differ, except in the division into chapters. They therefore proceeded in decyphering the remaining part of the characters, and, after much time and labour, obtained twenty-nine complete articles, in addition to the twenty-nine recollected by Foo-seng, making the fifty-eight chapters of which the *Shoo-king* at the present day is composed.

The story is told by Chinese writers with some variations; but it is a common saying, that "both the ancient and modern *Shoo-king* were taken from the wall of a house." According to some, the old man Foo-seng hid a copy of the book within the wall of his house, and, to avoid the rigour of the persecution that was carried on against men of letters, put out his own eyes and affected idiotism. The whole story, however, is not very consistent, and it has been conjectured that it was invented as a salvo to the mortified vanity of the Chinese, who were unable to make out a connected series of annals from a high antiquity; and that, in fact, Confucius was

the first regular historian of the empire, and probably the person who first led them on rapidly to a state of civilization. One thing, at least, is perfectly well ascertained; no writings of any description prior to those ascribed to Confucius, exist in China. Where the *Shoo-king* terminated, Confucius commenced his own annals, called the *Tchun-iou*, which carried down the history of the empire to his own time, and, of this work, a copy had been secreted by one of the historiographers. Many other manuscripts were from time to time brought in, from which were selected all that belonged to the history of the empire, by a commission, of which *Tse-ma-tsin* was placed at the head; after his death, his son *Tse-ma-tsien* completed this great work about a century before the Christian era, which is still extant, and its author considered and known by the name of the *Restorer of History*. From that period to the present time, there seems to be no reason to doubt the authenticity of Chinese history, or to accuse it of undue partiality. The history of a dynasty is not made public from authority, until that dynasty has ceased to reign; and it does not appear that any injustice is done or attempted by the succeeding dynasty. Some of the atrocities of Gengis Khan are related on his first incursion into China, but ample justice is done to him and to his successors. And the present Tartar dynasty, in publishing the annals of that of *Ming*, whom they displaced, does not appear to have done it any violent injustice. This event occurred under the eye of several European missionaries, then resident in the capital; and, by their concurring testimonies, the affairs of the empire were left, as the Chinese state, to priests, and eunuchs, and jugglers; and it is favourable to the character of the college of Han-lin, that, for the sake of accuracy, the history of the dynasty of Ming was retarded for some time by the Chinese members refusing to allow the Tartar race, then on the throne, the title of *imperial*, until the last remaining prince of the family of Ming should be extinct; but the Tartars insisted on dating the commencement of their own dynasty from the day they were in possession of Pekin; to which at length the Chinese members were reluctantly compelled to assent. In the instance of Gengis-khan, they were more successful. The name of this marauder does not appear in the list of Chinese Emperors, nor those of the two next in succession, Ogdai-khan, and Menko-khan, though their exploits are amply detailed in Chinese history. The Mongoo dynasty commences only with Kublai-khan, who was not declared emperor till the death of the last remaining branch of the family of *Song*. Their account of these Tartars is probably very correct. They had neither treasure to pay their troops, nor magazines of provisions for their subsistence. They lived by the chace and by plunder, driving before them large herds of cattle, whose flesh served them for food when other supplies failed, and their skins for clothing. They put to death men, women, and children, without compunction, plundering the towns and villages through which they passed, and carrying off the young women; and when the Chinese took up a strong position in the passes of the mountains, it was the practice of Gengis-khan to seize all the old men, women, and children of the neighbouring country, and drive them forward at the head of his army, and thus approaching the Chinese under cover of their own friends and relations, succeed in coming upon them without their being able to strike a single blow. And it is added, that, had it not been for the remonstrances of a Chinese who had united his fortunes to those of the invaders, Gengis-khan had determined to put to death all the agriculturists for plowing up the ground and destroying the grass, on which his numerous cavalry was to be subsisted.

As their history relates solely to the internal events and transactions of the empire, and as their policy has been to exclude all communication with foreign nations, we have no means of verifying the facts that are related; but it is in favour of their accuracy to find a fact recorded in the progress of a revolution brought about by a change of dynasty, which is also related by an European traveller, who was himself a party in the transaction, and who is worthy of implicit credit in all that he states to have fallen under his own knowledge and observation Marco Polo states, that *Sian-foo* was taken by the Mongoos after a siege of three years, chiefly by the means of machines made by his father and uncle, which hurled stones of three hundred pounds in weight; and it is recorded in the history of China, that the city of Siang-yang held out against the troops of Koublai-khan for four years, but was at length reduced by means of certain machines for hurling stones of an extraordinary weight, constructed by one *Alihaya*, who had travelled to China from the western countries.

Another instance of the fidelity of the Chinese historians is affirmed by the faithful traveller Marco Polo. It is recorded that Kublai-khan adopted the Chinese manners and customs, and gave encouragement to the arts and sciences, commerce and manufactures; that he opened the ports of China to all foreigners; that he sent embassies and expeditions to almost every part of the world, and received tribute from the sovereigns of Pung-kia-la (Bengal), Soo-ma-ta-la (Sumatra), and Mal-la-kia (Malacca); subdued Corea, but failed in his expedition against Japan, or, as they call it, Ge-pun-quo, the kingdom of the rising sun; all of which will be found related in Marco Polo; whose accuracy in relating what was told him, appears in another Chinese book called *Fo-quo-kee*, a history of the kingdom of Fo, giving an account of the temples of India, visited by a Ho-chang or priest, in the fourth century, in which, among other things, is noticed the yells and musical strains made by invisible spirits in the great desert of Sha-moo, to frighten and bewilder the traveller; a fable repeated by Marco Polo, in speaking of the same desert, nine hundred years afterwards (*Hist. Gen.*; Morrison's *Dictionary*; Marco Polo.)

Government.

But whether the ancient history of China be true or false, whether Yao or Chun were real or fictitious personages, and Confucius the real author of the religious, moral, and political maxims ascribed to these sovereigns, the Chinese at least entertain no doubts on the subject; and on these maxims are all their

institutions founded, as we find them existing at the present day. In all these institutions may be discovered the traces of a primæval state of society. The leading features of the government still wear the stamp of the first rude attempts to restrain savage man within the pale of social life; paternal solicitude and protection on the part of the chief; obedience and service on that of the people. The same principles which their history states to have regulated the pastoral tribes of Fo-hee on the plains of Shen-see, 4000 years ago, actuate the measures of the Chinese government of the present day. A few modifications of the ancient patriarchal system has served to convert tribes of hunters and shepherds into a nation of agriculturists, and kept them so; for of all governments that the history of the world has made known, none have had that permanency and stability which China has enjoyed. Like other governments, the machine may occasionally have been enlarged; a few wheels may have been added; its movements sometimes disturbed; its operations impeded; and a spring or a wheel injured or destroyed; but the damage has soon been repaired, and without altering or improving the principles of the construction. Rebellion, revolution, and foreign conquest, have occasionally removed old families from, and placed new ones on, the vacant throne; and for a moment disturbed the movements of the machine, but a little time has generally restored the usual harmony of its operations. It becomes, therefore, an object of interest to inquire, on what principles and by what practice, the largest mass of population, which in any age or country has been united under one government, has been kept together in one bond of union, for a period of time extending far beyond that at which the history of the earliest European nations may be said to commence. It has assuredly not been owing to the superior virtues of its princes; for China has had its Neros and Caligulas as well as Rome; nor to the superior virtues of the people; for Chinese morality consists more in profession than in practice; and yet the affectation of superior virtues in the one, and of moral sentiment in the other, have gone far in giving support to the system of government and securing the permanency of the ancient institutions of the country.

Ancient usage, universally appealed to, is almost the only rule of conduct, and the only limitation or control prescribed to the executive authority vested in the monarch. The public voice is never heard, but the public opinion is sedulously courted by the sovereign, and conveyed to every part of the empire through the medium of the *Pekin Gazette*. This vehicle of imperial panegyric is published daily; it is sent forth into all the provinces, and read in all the public taverns and tea-houses. It is one of the most powerful engines of state; and a series of this paper would explain the nature of the government, better than all the moral maxims of antiquity on which it is supposed to be founded. Through it are all the measures of the government, or rather of the sovereign, communicated to the public. If he fasts or feasts, promotes or degrades, levies or remits taxes, feeds the hungry, clothes the naked, rewards virtue, or punishes vice, or, in short, whatever laudable action he may perform, it is announced in this state paper, with the motives and the reasons that may have given rise to it. Every sentence of death, with an abstract of the charges and the trial, every mitigation of punishment, are also published in this Gazette.

The grand leading principle of this patriarchal Government is to place the Sovereign at as great a distance from the people, and as far removed from mortality, as human invention could suggest. They not only stile him, the "Son of Heaven," but believe him to be of heavenly descent; and this superstitious notion appeared in a manner sufficiently remarkable, by the obstacles thrown in the way of the present Mantchoo dynasty, on account of their family not being able to trace their descent farther back than eight generations; a defect of ancient origin, which was considered by the Chinese as a great reproach. Kaung-hee, aware of their prejudices, caused the genealogy of the Tartar family to be published in the Gazette. It stated that "the daughter of heaven, descending on the borders of the lake Poulkouri, at the foot of the White Mountain, and eating some red-fruit that grows there, conceived, and bore a son, partaking of her nature, and endowed with wisdom, strength, and beauty; that the people chose him for their Sovereign, and that from him were descended the present 'Son of Heaven,' who filled the throne of China." And this explanation wiped away the reproach, and fully satisfied the subjects of the "celestial Empire."

In the capacity of Sovereign, the Emperor of China is supposed to sustain two distinct characters. The first is that of a High Priest, in which he, and he alone, mediates and intercedes with heaven for all the sins and misdeeds of his people. In this character he only can officiate at solemn feasts, when heaven is to be propitiated by suitable oblations. He alone has the merit of all the prosperity that the empire enjoys; but he also affects to consider public calamity to be the consequence of some act committed, or some duty neglected by him. When, therefore, insurrections, famines, earthquakes, or inundations, afflict the people, he affects the deepest humility, appears in the meanest dress, strips the palace of its ornaments, and suspends all the Court amusements; but even in this state of humiliation, he is held up as the peculiar object of heaven's attention, whether it be to punish or to bless.

His second character as Sovereign of the Empire is that of "the father and mother of his people." In this character, it is supposed, that his subjects bear the same relation to him that he stands in towards *Tien* or heaven. His ministers or magistrates execute his will, and are supposed to be placed as agents between him and the people, in the same manner as heaven has its agents to regulate the divine decrees on earth; but all power, honour, offices, and emoluments, emanate from him alone, and are revocable at his pleasure. His prerogative is undefined and undivided, unrestrained by any written law, and checked only by ancient custom, stronger even than law. "Heaven," says Confucius, has not two sons, earth has not two kings, a family has not two masters, sovereign power has not

two directors—one God, one Emperor," not for China alone, but for all the earth, the rest of the Sovereigns being considered as his vassals. This doctrine was boldly avowed on the occasion of Lord Amherst's embassy, when the ceremony of prostration was demanded, not as a mere ceremony, but as the sign and seal of vassalage; and, on this ground, was, of course, resisted.

This self-created universal autocrat is not only the fountain of all honour in his wide dominions, but of all mercy. He is held up, on all occasions, as the mediator for his people, stepping in between the sentence of the law and the execution of it, and with a fatherly tenderness remitting a certain portion of the punishment which the law awards, and which the magistrate has no power to dispense with. If a magistrate instructs the people, it is in the name of the Emperor; if he flogs them for a misdemeanour, he remits a certain number of blows as the Emperor's grace; he orders his ministers to attend at all times to the complaints of the people; and that none may be denied access to the chief magistrate of the district, a gong or drum is suspended at the outer gate of his dwelling,—but woe be to him who ventures to sound it without substantial reason—the Emperor's grace would not save him from at least a dozen strokes of the bamboo. Navarette says that the judge's drum at Nankin is covered with the hide of an elephant, and the drum-stick, a huge piece of timber, slung by strong ropes from the roof of the house. This poor Jesuit had a ready credulity to receive all for truth which the Chinese told him.

The name of the sovereign, however, rarely appears but in an amiable light; the people hear of him only as distributing rewards, punishing oppression, relieving the distresses of the poor, opening the public magazines in times of scarcity, and remitting all taxes where the state of the treasury will afford it. Thus, it appears, that Kien-lung, having received a report from the Board of Revenue, that a balance remained in the treasury of seventy millions of ounces of silver, issued an edict, by which he exempted all his people from one year's taxes. This is all very good, and so is the whole theory of this arbitrary government, as delivered in the following rescript, which the minister of Timour-khan put into the hands of this sovereign; were but the practice conformable with it, we might call it truly Utopian. 1. Study with eager attention the will of heaven. 2. Be careful to tread in the steps of your ancestors, and to imitate their virtues. 3. Cease not to show your respect and gratitude to the august parents who gave you birth. 4. Watch over your people with a fatherly fondness. 5. In the exercise of sovereign power, preserve an upright heart, and an elevated soul. 6. Be moderate in your pleasures. 7. Drink little wine. 8. Do not lavish your treasures. 9. Extend your benefits to men of merit. 10. Make your justice formidable to criminals. 11. Drive from your presence knaves and flatterers. 12. Cherish upright and sincere men, and receive with temper their wise remonstrances. 13. Study the character of those you employ, and proportion their employments to their talents. 14. Regulate your time to your occupations, so that they may suit each other. 15. Let not a day pass without studying the maxims of the ancients. And he concludes by observing that, by putting in practice these fifteen precepts, he would secure to himself a happy reign, and to his people prosperity and the blessings of peace.

In Kaung-hee's declaration on the appointment of his successor, a short time previous to his death, he observes, that "the true way for a sovereign to perform his essential duty towards heaven and the memory of his ancestors, is to procure for the people peace and plenty; to make his own happiness consist in the happiness of the people, and his own heart the heart of the whole state;" and he adds, "although, since I have occupied the throne, I cannot say that I have succeeded in changing the bad customs, and reforming the morals of my people; although I may not have been fortunate enough to give plenty to every family, or the necessaries of life to every individual, yet I may venture to assert, that, during my long reign, I have had no other view than to procure for the empire a solid peace, and to render all my people satisfied in their respective conditions. During my whole reign, I have caused the death of no one without a sufficient reason. I have never ventured upon any useless expence to be defrayed from the public treasury; it is the blood of the people. I have drawn nothing from it that was not necessary for the subsistence of the army, and for relieving the calamities of famine," &c. &c.

The ancient and established maxims of filial piety form, however, the grand basis of the Chinese government. Every son is supposed to hold the same relation to his father that the people do to the sovereign; and the same unnatural and unwarrantable power which is given to the father over his children could not consistently be withheld from the emperor. No wickedness or unnatural treatment can, on the part of the parent, relieve a son from his duties. The merit of every good action performed by the son is ascribed to the education given to him by the father, but the son bears his own disgrace. In like manner, the sovereign receives the whole merit of the country's prosperity, but his ministers incur the disgrace of all its misfortunes. To be consistent in thus placing the young and vigorous at the mercy of the old and feeble, the Emperor affects to pay the same homage and obedience to his mother, that are due from children towards their parents. The effect of this state morality, destructive of all real sentiment, is that of rendering every man a slave to some other, and establishing a system of tyranny, descending in an uninterrupted chain from the Emperor down to the meanest peasant. But this is not the worst; every man distrusts his neighbour; because every man is known to assume a character that does not belong to him, and constantly to act the hypocrite in public.

The jealousy and suspicion which prevails from the sovereign on the throne to the lowest of the magistrates, evince how little they trust to the fine maxims of morality, by which it is pretended the throne is supported, and the happiness of the people secured. No magistrate, for instance, can hold an employment in a district where he has relations; he cannot marry in that district; he cannot pur-

chase lands in it; if his father or his mother should die, he must immediately resign his employment to fulfil the duties which a son owes to his parents, and which cease not with life; and, at all events, he is removed at the end of three years. No two relations within the fourth degree can sit together at the same board. In each of the six boards, which sit in Pekin, there is a censor, who has no deliberative voice, but listens to their discussions, makes his remarks, and, like our speaker in the House of Commons, keeps them in order, refers to precedents, &c. He is supposed to be the confidential servant of the Sovereign, from whom he is informed of what is going on, and what are the sentiments of the several members. These six *Co-laos* may be considered as imperial spies, and they form an extraordinary board called *Too-tche-yuen*, whose chief business is that of dispatching their visitors or sub-censors to all parts of the empire, to examine into and report upon the conduct of the several officers, and to discover whether any and what abuses are alleged against them; and, to complete the system of espionage, persons are invited to send up informations against the officers of government, all of which are registered in this extraordinary tribunal.

In this precarious situation, a magistrate may consider himself fortunate if he escapes the shafts of private malice, or retires from office without having incurred disgrace or some more serious punishment for the commission of some fault, or the dereliction of some duty; for, where the offices of state are open to the lowest of the people, when possessed of the requisite qualifications, the candidates for employment become so numerous, that every trifling fault is laid hold of to create a vacancy; and these frequent removals and degradations fall in precisely with the system of the government, which is to break down all connection between the officers and the people, and to turn the respect and veneration of the latter exclusively to the Sovereign. On the same principle, it is supposed that the extortions and malversations of officers high in the government are frequently winked at, until, at a proper season, the hand of power lays hold of the treasure corruptly obtained, and gets rid, in a legal manner, of the whole family of the delinquent. It is true, a magistrate in China is tried by his brother magistrates, but when the Sovereign is the accuser, as is generally the case where an officer of state is the accused, the result is pretty certain. The favourite and principal adviser of the late Kien-Lung was brought to trial by the present Emperor Kia-King on charges of the most frivolous nature, as that of having walked through the middle gate, which is alone reserved for the Emperor, having a pearl in his possession larger than any belonging to the imperial family, &c.; but the object was answered; he was condemned to death, his whole property, which was immense, confiscated, all his relations dismissed from their employments, and banished into Tartary. We may form a tolerably correct opinion of the manner in which the criminal courts administer justice in cases wherein the Emperor is personally concerned, from the trials that took place in consequence of the recent attempt that was made to assassinate Kia-King. He announces to the public a revolt, takes blame to himself, abuses his ministers for their negligence, to which he ascribes his misfortune, and ends his proclamation in a strain of self-reproach, and great hypocritical humility. As the greater part of the handful of rebels who attempted to storm the palace were killed in the act, and the rest that were taken put to death, some by beheading, others by a slow and lingering process, some hacked and mutilated in the public market-place, and others "cut into ten thousand pieces," it might be supposed that here the business ended; no such thing. The Emperor, in his proclamation, denounces a particular sect which once caused a revolt in four provinces that took eight years to subdue; hence the country magistrates, to make amends for the carelessness of the ministers, persecuted all sects, and among others the Christians. One of the magistrates had the courage to send to the capital a spirited remonstrance, in which he stated that many innocent persons had been brought to trial, tortured, and suffered death; that numbers were unjustly confined, passed from court to court, after being put to the torture under pretence of preparation for trial; and that they were finally liberated, without trial, after their health was destroyed, and their property wasted. The whole document exhibits a melancholy picture of abuses in the administration of the criminal jurisprudence of this supposed virtuous and humane nation.

The administration of the government is conducted by six departments, to each of which there is a president and a certain number of members, forming so many boards similar to those of our Admiralty and Treasury Boards; and the six presidents form a distinct board of themselves, which, with certain Princes of the Blood, may be called the extraordinary Council of the State. Each board sends out its appropriate officers to every part of the Empire, with and from whom it has to correspond, and receive reports; abstracts of which, and of all its proceedings, are daily laid before the Emperor by one of the Collaos or Presidents, whom he generally selects as his favourite and confidential minister and adviser. The respective duties of these boards are so interwoven with the laws of the Empire, that a brief view of the laws will best explain the nature of the executive governments. (Grozier and Du Halde's *Hist. of China.*—*Mém. sur les Chinois.*—Macartney's *Journal.*—Staunton's *Authentic Account of an Embassy*, &c.—Barrow's *Travels in China.*)

Laws.

When Pauw observed that China was governed by the whip and the bamboo, he was not aware of the theoretical application of these instruments, especially the latter, to the whole code of civil and criminal law. The remark was not meant to extend beyond the practical application of these machines to the human body, which, it must be owned, are effectual aids towards the establishment of a strict police, and that they are freely enough administered in keeping the peace among the lower orders; but their use in this way is by no means so extensive as is generally supposed, and as the letter of the law would seem to imply. This great empire may, notwithstanding, be aptly enough compared to a great school, of which the magistrates are the masters, and the people the scholars. The bamboo is the ferula,

and care is taken that the child shall not be spoiled by sparing the rod. The bamboo, however, is not used merely for flogging the people. In the fundamental laws of the empire, it forms the scale by which all punishments are supposed to be proportioned to the crimes committed, and which are carefully dealt out by weight and measure; and here also we recognise the work of an ancient people in a rude state of society. In a small family, or a community consisting of a certain number of families, it may just be possible to "adapt the penalties of the laws in a just proportion to the crimes against which they are denounced;" but the continuance of such a system in an overgrown commonwealth affords no proof of refined or extensive notions of jurisprudence. Punishment, as an example to deter others from the commission of crimes, would seem indeed to be less the object of Chinese legislation, than that of satisfying the claims of rigid justice; to wipe off a certain degree of crime by the infliction of a proportionate degree of suffering.

The code of laws called the *Leu-lee* has undergone several changes by different dynasties, but the principle of the laws has remained the same. This book is to China what "Burns's *Justice*" is in England, and is familiar to all who have any pretensions to literature. "The magistrates and the people," says the Emperor Sun-chec, "look up with awe and submission to the justice of these institutions." An European will regard them with different feelings. The frequency and the severity of corporal punishments, if literally inflicted, would be shocking and disgusting; but, as Sir G. Staunton has observed, "there are so many grounds of mitigation, so many exceptions in favour of particular classes, and in consideration of peculiar circumstances, that the penal system, in fact, almost entirely abandons that part of its outward and apparent character." The same observation will apply to the penalty of death, which appears to be affixed to crimes whose enormity are not such as would be deemed worthy of this extreme of punishment in the most sanguinary code of Europe; for if we are to judge from the very small comparative number of criminals that are annually executed, one of two conclusions must necessarily be drawn, either that capital offences are very rare, or that the laws are very lenient. Pere Amiot says, that, in 1784, the list of criminals under sentence of death, and ratified by the emperor, amounted to 1348 persons, which, he observes, was considered to be unusually great. It is about one in 108,000, at which rate not more than 160 would suffer annually in the whole population of Great Britain and Ireland.

The number of blows to be inflicted with the bamboo may not only be considered as the measure or scale of crimes, but as regulating also the mode or practice of punishment. The letter of the law, severe as it may appear to be in denunciation, is more lenient in execution. Thus, ten blows of nominal punishment are practically reduced to four, and 100 to 40; and, in many cases, these blows are redeemable by fine.

This bamboo, that makes so conspicuous a figure in the Chinese code, is limited by law to two sizes; the larger 5 feet 8 inches in length, $2\frac{3}{4}$ inches broad, and 2 inches thick, weighing $2\frac{2}{3}$ pounds; the smaller the same length, 2 inches broad, and $1\frac{1}{5}$ thick, weight about $1\frac{5}{6}$ pound.

The cangue, or more properly the *kia*, is a wooden collar for the neck, 3 feet long, 2 feet 9 inches broad, weighing in ordinary cases 33 pounds.

The iron chain, by which all criminals are confined, is 7 feet long, weighing $6\frac{2}{5}$ pounds; besides which they use wooden handcuffs and iron fetters.

Various kinds of torture of the hands, feet, ankles, &c. are made use of to extort evidence or confession; but it is not permitted to put the question by torture to those who belong to any of the eight privileged classes, in consideration of the respect due to their character; nor to those who have attained their 70th year, in consideration of their advanced age; nor to those who have not exceeded their 15th year, out of indulgence to their tender youth; nor, lastly, to those who labour under any permanent disease or infirmity, out of commiseration for their situation and sufferings. The eight privileged orders spring out of, 1. Imperial blood and connexions. 2. Long service. 3. Illustrious actions. 4. Extraordinary wisdom. 5. Great abilities. 6. Zeal and assiduity. 7. Nobility of the first, second, and third rank. 8. Birth—all of which, excepting the first, seventh, and eighth, have not, in fact, any existence. Their chief privilege consists in not being liable to be tried for any offence without a specification of the crime being laid before the emperor, and his express commands issued for that purpose.

There are five degrees of punishment.

The first degree is a moderate correction inflicted with the lesser bamboo, "in order that the transgressor of the law may entertain a sense of shame for his past, and receive a salutary admonition with respect to his future conduct." This correction extends from ten to fifty blows; the first, in practice, reduced to four by the emperor's grace; the last never exceeds twenty blows.

The second class of punishments extends from sixty to a hundred blows, of which from twenty to forty are actually inflicted.

The third division is that of temporary banishment to any distance not exceeding 500 *lee* (about 150 miles), "with the view of affording opportunities of repentance and amendment," and it extends from one to three years' banishment.

The fourth degree of punishment is that of perpetual banishment, which is reserved for the more considerable offences, and extends to the distance of 2000 and even 3000 *lee*, with 100 blows of the bamboo.

The fifth and ultimate punishment which the laws ordain, is death, either by strangulation or decollation.

At the head of the code are placed *ten* offences of a *treasonable nature*. 1. *Rebellion*, defined an attempt to violate the divine order of things on earth. 2. *Disloyalty*, an attempt to destroy the imperial palaces, temples, or tombs. 3. *Desertion* to a foreign power. 4. *Parricide*, or the murder of parents, uncle, aunt, grandfather, or grandmother. 5. *Massacre*, or the murder of three or more persons in one family. 6. *Sacrilege*, or stealing from the temples any sacred article, or anything in the immediate use of

the sovereign. 7. *Impiety*, or negligence and disrespect of parents. 8. *Discord in families*, or a breach of the legal or natural ties, founded on connections by blood or marriage. 9. *Insurrection* against the magistrates. 10. *Incest*, or cohabitation of persons related in any of the degrees to which marriage is prohibited. And these crimes are stated to be placed at the head of the code, from their being of so heinous a kind, that, when the offence is capital, it is exempted from the benefit of any act of general pardon, and that the people may learn to dread and avoid them.

Offences committed by officers of government, which, in ordinary cases, are punishable by the bamboo, are commutable for fine or degradation, according to the number of blows to which they are nominally liable. Thus, if publicly offending, instead of 60 blows, they forfeit a year's salary; and, instead of a hundred, lose four degrees of rank, and are removed from their situation. If the offence be of a private nature, the punishment is doubled. The only male descendant of parents or grandparents, who are aged and infirm men, whose age exceeds 70, and youths under 16, are entitled to the indulgence of commuting the punishment awarded by law. Women too may have the sentence of banishment remitted on payment of a fine; and, when convicted of offences punishable with the bamboo, "they are permitted to retain a single upper garment while the punishment is inflicted, except in cases of adultery, when they shall be allowed the lower garment only."

The following table exhibits a scale of pecuniary redemption, in cases not legally excluded from the benefit of general acts of grace and pardon. They are not necessarily redeemable; but, by edict of *Kien Lung*, may be made so upon petition.

Rank of the party offending.	Sentence.	Pecuniary Commutation. Oz. of Silv.
An officer above the 4th rank	Death by strangulation or decollation.	12,000
—— of the 4th rank		5,000
—— of the 5th or 6th rank		4,000
—— of the 7th, or any inferior rank, or a doctor of literature - -		2,500
A graduate or licenciate		2,000
A private individual -		1,200
An officer above the 4th rank	Perpetual banishment.	7,200
—— of the 4th rank		3,000
—— of the 5th or 6th rank		2,400
—— of the 7th, or any inferior rank, or a doctor of literature - -		1,500
A graduate or licenciate		1,200
A private individual -		720
An officer above the 4th rank	Temporary banishment, or blows with the bamboo.	4,800
—— of the 4th rank		2,000
—— of the 5th or 6th rank		1,600
—— of the 7th or any inferior rank, or a doctor of literature - -		1,000
A graduate or licenciate		800
A private individual -		480

There is every reason to believe that these pecuniary commutations of banishments bring considerable sums into the treasury.

The *Ta-tsing-leu-lee* embraces an epitome of the whole system of government, and of civil and criminal jurisprudence. Besides the introductory part, which contains a general view of the laws, the code consists of six principal divisions, corresponding with the six supreme boards or departments, by which the general administration of the empire is conducted. Thus, the *first division* of the code relates to that part of the *civil law*, which falls under the cognizance of the *Lee-pou*, or the department which examines candidates for employment, and nominates to appointments, subject to the approbation of the emperor. This division consists of two chapters, the first defining the duties, and regulating the offices, of the several magistrates, the rule of hereditary succession, and the penalties attached to malversation. The second book relates chiefly to the conduct of the provincial magistrates. The capital offences classed under this division are, great officers of state presuming to confer appointments on their own authority, and without the sanction of the emperor; undue solicitation of hereditary honours; all cabals and state intrigues among the officers of government; collusion between the provincial magistrates and the officers of the court; addressing the emperor in favour of any great officer of state, which is construed into a treasonable combination, subversive of legitimate government; destroying edicts or seals of office; all of which, however, fall within the class of redeemable punishments, which are not excluded from any general act of grace or pardon.

The *second division* of the code relates to the *Fiscal Laws*, which are placed under the cognizance of the *Hoo-pou*, or financial department. They are very various, and relate—1. To the enrolment of the people; personal service; levying of taxes; punishment of persons deserting their families; care of the aged and infirm. 2. The law of holding, mortgaging, selling, &c. lands and tenements. 3. Regulations respecting marriages and divorces. 4. Respecting public property, the coinage, the revenue, the public stores. 5. Duties and customs; smuggling; false manifests, &c. 6. Private property: the law of usury; of trusts, &c. 7. The regulations concerning sales and markets; monopolizing and fraudulent traders; false weights, measures, and scales; manufactures not conformable to the fixed standard, &c. The section concerning marriages and divorces is brought under this division of the code, for no other reason, it would seem, than to regulate the descent and distribution of property. The law allows seven justifiable causes of divorce. 1. Barrenness; 2. lasciviousness; 3. neglect of her husband's parents; 4. talkativeness; 5. thievish propensities; 6. envious and jealous temper; 7. inveterate infirmity. But, in spite of any or all of these causes, a wife cannot be divorced, if she can plead any of the three cases; 1. having mourned three years for her husband's parents; 2. her husband having become rich since the time of marriage; 3. the wife having no parents living to receive her.

The *Le-pou*, or board of rites and ceremonies, takes cognizance of all offences committed under the *third division* of the code, which is subdivided into two

sections; and relate, 1. To the *sacred rites;* the administration of the prescribed ritual; the care of altars, sacred terraces, and the tombs; unlicensed forms of worship; magicians; leaders of sects; and teachers of false doctrines. 2. To miscellaneous observances respecting the palaces, the Emperor, his equipage, and furniture; to the public festivals and days of ceremony; sumptuary laws, relative to dress and habitations; celestial observations and appearances; regulations for funerals and country festivals.

The *fourth division* contains the laws by which the military are governed, the direction and superintendence of which are placed under the department of state called the *ping-pou.* It consists of five sections. The first relates to the protection of the palace, and of course to the person of the Emperor; the duties of the imperial guards; examination of passports, &c. The second is entitled the *government of the army*, and may be considered as the mutiny act, or articles of war, of China. Every neglect of duty, disobedience of orders, and want of discipline; fraud, embezzlement, desertion, are punished with extreme severity, and many of the offences herein specified are capital. The third section relates to the *protection of the frontier*, a most important consideration with this suspicious government. The fourth prescribes regulations respecting the horses and cattle belonging to the army. The fifth for the expresses and government posts, the post-horses, messengers, and horses, employed in the conveyance of dispatches.

The *fifth division* contains the Code of Criminal Law, administered by the *Hing-pou*, or criminal tribunal, which supplies the judges or assessors to all the other departments. It consists of eleven sections. The first, entitled *robbery and theft*, awards punishments for every species of robbery or theft that could well be devised; extorting property by threats; obtaining it under false pretences; kidnapping and selling free persons as slaves; disturbing graves, &c. The second relates to *homicide*, and may be considered as a most singular, if not successful, attempt to discriminate the exact proportion of guilt, for the same offence, in different persons, or different degrees of offence in the same person, according to the situation and circumstances of the offending parties. In every case of preconcerted homicide, the original contriver is condemned to die by decapitation; the accessaries by strangulation; accessaries to the intention, but not to the fact, are punishable with one hundred blows, and perpetual banishment. Those who murder, with intent to rob, are beheaded, without distinction between principals and accessaries. Parricide subjects all parties to suffer death by a slow and painful execution; the attempt to commit parricide is death by decapitation. Slaves attempting to murder, or actually murdering their masters, are liable to the same punishment. A husband may kill his wife, if caught in the act of adultery, and also her paramour; and a thief may be put to death, if taken in the act of robbing a house; but, in either case, it would be murder, if put to death after being seized. The preparing of poisons, or rearing of venomous animals, are capital offences. Practitioners of physic, or barbers (for they have no surgeons), who puncture with the needle, giving drugs, or performing operations contrary to the established rules and practice, and thereby killing the patient, are guilty of homicide; but, if proved to have been merely an error in judgment, the offence is redeemable by fine, but the doctor and the barber must quit their professions for ever; but, if the medicines were given intentionally to kill or injure the patient, the practitioner must suffer death by decapitation. All persons guilty of killing in an affray, though without any express or implied design to kill, whether the blow be given with the hand or the foot, with a metal weapon or instrument of any kind, shall suffer death by strangulation. There is a clause, however, by which all persons killing another in play, by error, or purely by accident, may be permitted to redeem themselves from the punishment of killing or wounding in an affray, by the payment of a fine to the family of the deceased person; but the case of *pure accident* is very carefully defined and exemplified. It must be one "of which no sufficient previous warning could be given, either directly, by the perception of sight and hearing, or indirectly, by the inferences drawn from judgment and reflection."

In the third section, entitled "Quarrelling and Fighting," there is a minute and circumstantial detail of blows given under every conceivable case and situation, and in every possible relation in which the parties could stand towards each other. It fixes the periods of responsibility for the consequences of a wound; it awards the penalty of death on a slave who shall strike his master; on a son who shall strike his father or mother; on a grandson who shall strike his paternal grandfather or grandmother; on a wife who shall strike her husband's father, mother, paternal grandfather or grandmother; but, if a father, mother, paternal grandfather, or grandmother, shall chastise a disobedient child or grandchild in a severe and uncustomary manner, so that he or she dies, the party so offending shall be punished only with one hundred blows, which, in reality, are no more than forty; and, when any of the aforesaid relations are guilty of killing such disobedient child or grandchild designedly, the punishment shall be extended to sixty blows, and one year's banishment. A parent may, at any time, sell his children, with the exception only to strolling players, and professors of the magic art. This distinction which the law makes between the parent and child, and the almost unlimited authority which is given to the former over the latter, would lead one to conclude, that, if the crime of infanticide be not sanctioned, it is at least connived at, by the government. There is every reason, however, to believe that the extent of it has been grossly exaggerated, and that the greater part of infants taken up in the streets of large cities by the police have died in the birth, and been laid out, to avoid the expence of burial; or been exposed alive, with the view of their being taken care of as adopted children, or conveyed to hospitals for the reception of deserted children.

In the cases above stated, the child murdered is supposed to have been *disobedient*, which is a crime of the deepest dye, as affecting the principle on which the whole system of government is founded;

but from section 294, it is evident, that killing a son, grandson, or slave, under any circumstances, with the aggravation of imputing his death to an innocent person, is not a capital offence. "Whoever is guilty of killing his son, his grandson, or his slave, and attributing the crime to another person, shall be punished with seventy blows, and one and a half year's banishment." But "a child or grandchild, who is guilty of addressing *abusive language* to his or her father or mother, paternal grandfather or grandmother; a wife who is guilty of addressing abusive language to her husband's father or mother, paternal grandfather or grandmother, shall, in every case, suffer death, by being strangled." They must, however, themselves complain, and themselves have heard the abusive language. In like manner, a slave is liable to capital punishment for addressing abusive language to his master.

The fifth book relates to Indictments and Informations of all kinds; the sixth to cases of Bribery and Corruption, and seems to contain provisions against bribery in almost every shape which it can be supposed to assume. It is not easy, however, to reconcile these apparent appropriate provisions with that systematic corruption which, under the less odious name of presents, is prevalent in every department of the administration of public affairs and public justice in China. There is a scale of punishment for the value of the bribe received, from one ounce of silver to 120 and upwards; the first entailing sixty blows, the last death, by strangulation, when the object is in itself lawful; but, if unlawful, an ounce of silver incurs seventy blows; and eighty ounces and upwards death, by strangulation. That they all take bribes is well known, yet it appears by a note in the original *(Leu-lee)*, that, in the 33d year of Kien-lung, a governor of a city in the province of the capital was tried, and sentenced to suffer death, for taking a bribe of 7000 ounces of silver to stop proceedings in a case of disorderly conduct, and contempt of court; though, finding himself unable to accomplish the object, he had returned the money. In like manner, there are so many provisions against extortions, and corrupt practices on the part of great officers of state and their families, that it might be supposed no such practices could exist. The last section of this book is curious, as affording a proof of the care with which the imperial prerogative is fenced round. "All military officers of government, whether stationed at Court or in the provinces, are prohibited from receiving presents of gold, silver, silk-stuffs, clothes, wages, or board-wages, from individuals in any of the three principal ranks of hereditary nobility" (mostly related to the royal family and other Tartar chieftains). Any breach of this law deprives them of their rank and employment, and renders them, moreover, liable to the punishment of one hundred blows, and remote perpetual banishment. The second offence of this kind is capital.

The seventh book awards punishment for frauds and forgeries, falsification of the imperial seal or imperial almanac, counterfeiting the current coin of the realm, seducing persons to transgress the laws, &c. The eighth is entitled Incest and Adultery. Criminal intercourse with an unmarried woman, though by mutual consent, is punishable with seventy blows; with a married woman, eighty blows; deliberate intrigue with either, with one hundred blows; a rape with death, by strangulation; and criminal intercourse with a girl under twelve years of age is punishable as a rape. Adultery with the wife of any civil or military officer is death; but civil or military officers committing adultery with the wife of a private individual is degradation, one hundred blows, and wearing the cangue for a month. In all ordinary cases of adultery among the people, the punishment is one hundred blows, and the cangue for a month. An unnatural crime forcibly committed, or committed on boys, is punishable as a rape; but by mutual consent the parties are punishable only with one hundred blows, and the cangue for a month. In all cases of criminal intercourse, the law is more severe towards the woman than the man, and towards slaves than freemen. "All civil or military officers of government, and the sons of those who possess hereditary rank, who shall frequent the company of prostitutes and actresses, shall be punished with sixty blows;" which is, in fact, no punishment at all, as the blows, in reality, are reduced to twenty, and redeemable for a mere nominal sum, not exceeding two or three shillings.

The ninth book is entitled Miscellaneous Offences, among which is that of gaming; any person convicted of which is punishable with eighty blows. Yet in every street and corner, and in the very temples, the lowest of the people may be seen daily, and every hour of the day, playing at cards, dice, or a sort of game resembling chess. Accidental incendiaries are flogged, and fined, according to the consequences of the fire they have occasioned; and wilful incendiaries are punished with death, provided it be proved that the fire was occasioned with a view of plunder. Stage-players and musicians are prohibited from representing emperors, empresses, famous princes, ministers, and generals of former ages, on pain of receiving one hundred blows for every breach of this law. Yet, as these are the favourite and most usual exhibitions, it may be presumed that this law is obsolete; there is, indeed, a saving clause which says, "that, by this law, it is not intended to prohibit the exhibition on the stage of fictitious characters of just and upright men, of chaste wives, and pious and obedient children; all which may tend to dispose the minds of the spectators to the practice of virtue."

The tenth and eleventh sections contain regulations with regard to arrests and escapes, imprisonment, judgment, and execution.

The *sixth and last division* contains the laws and regulations respecting the public works, which are placed under the superintendence of the department of state, called the *Cong-poo*, or board of public works. It has only two sections; the first relating to public buildings, the second to the public roads. From the first it appears, that this board has also the superintendence of the public manufactures of the state, such as military weapons, silks, stuffs, porcelain, &c.; and that, if any private individual be convicted of manufacturing for sale silks, satins, gauzes,

or other stuffs of this nature, according to the prohibited pattern of the *lung* (dragon), or the *fung-whang* (phœnix), he shall incur the penalty of one hundred blows, and the goods so manufactured be forfeited to the state. This book and the next, concerning the keeping in repair of the public roads, embankments, and bridges, contain a number of regulations and petty penalties for neglect and malversation, that are beneath the dignity of legislation, and fitted rather for the subjects of deliberation in a parish vestry. Indeed, the whole body of Chinese law, civil and criminal, consists of such minute meddling with all the common concerns of life, as to be utterly unfit for any practical application, except to such mere machines as the Chinese are, for whom it seems to be admirably suited to answer the intended purpose. Nothing can more clearly exhibit this great multitude of human beings as an inert and sluggish mass, without a heart, and without one single idea of the liberty and independence of the human mind, than the minute and paltry regulations under which it has voluntarily submitted to be bound and shackled for so many thousand years.

After all, there is reason to suspect that this minute measuring out of punishments by a scale, in order to adapt them to their respective degrees of criminality, is pregnant with the most gross injustice; and that, where so much pains are ostentatiously displayed to deal out justice by weight and measure, there is so much less of it in the execution. Many examples might be cited in confirmation of this opinion, but a few will suffice. In the eleventh volume of the *Chinese Memoirs*, Pere Amiot gives a curious account of a master mason that died by an accidental blow of the bamboo, while under a flogging by order of an officer of the household of a prince of the blood, whose house he was rebuilding in Pekin. As culpable homicide is death by the law of China, the officer bribed one of the mason's labourers, for ten ounces of silver, and the promise of a respite, to take the blame on himself, as the consequence of a quarrel; and, for three ounces of silver, two or three of the labourers were to give evidence to that effect. The man was tried, and condemned to suffer death on the day of general execution in autumn. On the morning of that day, or the evening preceding, it is the custom, it seems, to bring up all the prisoners under sentence of death to be interrogated by the Colloas, or principal ministers of the crown; and, on this occasion, the heart of the bricklayer's labourer failing him, he discovered the whole transaction. The offending officer was immediately tried; and, coupling his original offence with the aggravated one of exposing an innocent person to suffer death, was sentenced to die by a slow and painful execution. Nor was this all; the judges and assessors of the court, who had originally tried the offence, were each degraded one rank, and mulcted of their salary and emoluments. This is given by Pere Amiot as an instance of Chinese justice; but it tells as strongly the other way, as, if such gross iniquity, committed in open day, and in the presence of a multitude, and thus connived at at the very fountain-head, what may not be expected at a distance, where the stream is still more muddy? That government can have no high notions of justice or morality, which winks at, and sometimes encourages, a criminal to find a substitute, even when the punishment is death. Many of the servants of the East India Company can testify, from their own personal knowledge, to the truth of the severe remark of Pauw—" Le juge veut faire une exécution, et il lui faut un patient; or il prend celui qui se présente." In the recent case of an English seaman being tried for the murder of a Chinese, when they failed in their endeavours to procure a black slave, or a criminal of Macao, or a sick person on the point of death, to execute,—not to satisfy justice, for it was an accidental death in a scuffle,—but to satisfy the criminal court of Pekin, to whom they had unluckily for themselves appealed; they had recourse to one of the meanest and most paltry expedients that ever disgraced a civilized government. " All the proceedings," says Sir G. Staunton, " were founded on a story fabricated for the purpose; a story in which the Europeans did not concur, though asserted to have done so; which, in fact, the Chinese magistrates themselves, or the merchants under their influence, invented; which the Chinese witnesses, knowing to be false, adopted; and which, lastly, the sovereign himself, appears to have acquiesced in, without examination." Under such a government, the laws are either a dead letter, or may be so perverted, that, under their sanction, the innocent may be made to suffer, and the guilty escape punishment.

In addition to all this, that horrible system of visiting the crimes of the guilty upon the heads of the innocent, which pervades all the despotic governments of the East, is also practised in China, in all cases of rebellion and treason; though it is not carried so far as among the Hindoos, who, not content with cutting off a whole family, swept away whole towns and villages in which treason had appeared, as a terrible example to prevent other villages from harbouring traitors. Such are the dreadful effects of despotism, and the miseries inflicted on innocent families, where the people have no voice in the government;—such a government is always more ready to punish than to protect. (*Ta-tsing-leu-lee*, translated by Sir G. Staunton.)

Prisons.

The condemned criminals for ordinary offences are kept in prison till autumn, when they are all executed in every part of the Empire on a particular day. In general, the prisons are described as spacious, neat, and clean. Navarette, who was himself confined in one of them, says, that they have large airy courts for the prisoners in the day-time; that overseers are always present to quell any noise or disturbance, and that they contain temples for the priests to resort to. The priests, he says, make a harvest in the prisons, as those whose trials were pending were constantly consulting the priests as to the issue, and they became the more religious, the nearer the day of trial approached. Criminals are kept in chains, and always apart; so are the women kept separate from the men; and the missionary observed so little gallantry on the part of the men, that though there were gratings in the doors of the women's cells, the Chinese never once visited them. A very different picture, however, is given of the

state of the prisons, and the prostitution of the females confined in them, in the province of Canton, from better authority than Navarette,—an official report to the Emperor on the state of the prisons. The scenes of depravity therein exhibited are horrible beyond description. *(MS. Report.)*

The durability of a system so arbitrary, and an administration so corrupt, is not a little owing to the incessant and indefatigable vigilance of the police; to the absence of all political meetings or societies, and of all discussions respecting public measures; to the gradation of obedience throughout every class of society, inculcated by precept, by example, and by the bamboo; and certainly not a little to that spirit of national industry, which is the grand preserver of national tranquillity.

Revenues.

It is utterly impossible, from any document that has appeared of an authentic nature, to form any estimation of the amount and value of the revenue. From an extract of the *Y-tung-tche* (Encyclopædia), translated by Mr Morrison, it appears, that the annual value of the imports amounts to about 36,000,000 leang (of 6s. 8d. each), or L. 12,000,000 Sterling; but whether this is exclusive of the taxes paid in kind to the public granaries and magazines, or whether these are included in that sum, it is not stated; but as the value of money is only about one-fourth part of its value in England, fifty millions of money, in an economical government like this, where the officers and magistrates are so shamefully paid that they could not live without robbing the people, may be considered as an ample revenue for all the necessities of the state. The largest sum arises from an impost of about one-tenth on the estimated produce of the land; a duty on salt yields about one-fourth of the land-tax; and the customs and minor taxes make up a sum altogether about equal to that of the salt-tax. Besides, grain, silks, cottons, and various manufactures, are paid in kind into the imperial magazines, and are distributed as clothing to the troops, and in part payment to the magistrates, and also as presents to those distinguished by imperial favour, and to foreign ambassadors. A forced loan, never to be repaid, and a capitation tax, the most unjust of all taxes, because the most unequal, are the odious resources to which the Chinese government is occasionally compelled to have recourse. The immense treasures supposed to have been amassed in Tartary by the reigning dynasty, exist only in the imagination of the Chinese.

Religion.

Religion, as a system of divine worship, as piety towards God, and as holding forth future rewards and punishments, can hardly be said to exist among the people. It is here, at least, neither a bond of union, nor a source of dissension. They have no sabbatical institution, no congregational worship; no external forms of devotion, of petition, or thanksgiving, to the Supreme Being; the Emperor,—and he alone, being high priest, and the only individual who stands between Heaven and the people, having the same relation to the former that the latter are supposed to bear to him,—performs the sacred duties, according to the ancient ritual, and at certain fixed periods; but the people have no concern with them. The Emperor alone officiates at all the solemn ceremonies, for propitiating Heaven, or expressing a grateful sense of its benefits; and as "Sacrifices and oblations can only be acceptable to heaven, when offered up with humble reverence, and a pure and upright heart," he prepares himself for such occasions by fasting and abstinence, and acts of benevolence and mercy to his subjects.

The equinoxes are the periods when the grand sacrifices in the temple dedicated to Heaven, within the precincts of the palace, are offered up; when every kind of business in the capital, all feasts, amusements, marriages, funerals, must be suspended during the ceremony, the moment of which is announced to the people by the tolling of the great bell in Pekin.

A ridiculous dispute was carried on with great vehemence between the Jesuits and other sectaries of the Catholic religion, whether the Emperor did not offer his sacrifices and oblations to *Tien* as the visible and material heaven, and whether the Chinese were not atheists, at the head of whom he was the officiating high priest. There is not an expression in their ancient book of rites that warrants such a supposition. The *Lee-Kee* describes the *Tien* as having neither voice, nor smell, nor figure, substance, nor dimensions; it gives him the attributes of omnipotence, omniscience, and ubiquity, and considers him as rewarding the good, and punishing the bad; that public calamities are the instruments he employs to excite in the sovereign, and through him in the people, a reformation of morals. The names by which the sovereign power is known in their writings is *Whang-tien*, the illustrious heaven; *Chang-tee*, the Supreme Ruler; *Tien-tee*, heaven and earth; *Che-chung*, the first and the last (Alpha and Omega); *Ken-puen*, root and branch. When the Jesuits asked the Emperor Kaung-hee, whether the sacrifices were made to the Sovereign Lord of Heaven, the author and preserver of all things; whether the ceremonies in the hall dedicated to Confucius, were in honour of his memory as a benefactor to his country; and whether the rites observed towards ancestors in the hall dedicated to them, were merely to show respect and gratitude?—Kaung-hee replied, that they comprehended very well the Chinese religion; but the prayer of *Kaung-hee*, before going into battle, and published in the Pekin Gazette, might have satisfied the most scrupulous. "Sovereign Lord of Heaven, the Supreme Ruler, receive my homage, and grant protection to the humblest of thy subjects. With respectful confidence, I invoke thy aid in a war which I am compelled to wage. Thou hast heaped on me thy favours, and hast distinguished me by thy special protection. A people without number acknowledges my power. I adore in silent devotion thy manifold kindnesses, but know not how to manifest the gratitude which I feel. The desire of my heart is to give to my people, and to let strangers enjoy, the blessings of peace; but the enemy has put an end to this my most cherished hope. Prostrate before thee, I implore thy succour, and, in making this humble oblation, I am animated with the hope of obtaining thy signal favour. My only wish is to procure a lasting peace throughout the immense region over which thou hast set me."

(*Hist. Gen. de la Chine*, Tom. II.) The inscription over the doors of the Jesuits' church in Pekin, "To the only true God," &c. written with *Kaung-hee's* own hand, affords farther proof of his sentiments respecting the Deity.

All ranks, however, from the Emperor downwards, are full of absurd superstitions. The imagination of untutored man, not easily comprehending a power so almighty and universal, created a number of inferior spiritual beings as the harbingers and agents of his will; and these spiritual agents, which the Chinese call *Quei-shin*, are invisible attenuated beings, some white and good, the advocates of men, others black and wicked, the punishers of sin; and these "illustrious subjects of the Great Ruler," are supposed to preside over the five seasons of the year, —over mountains and rivers,—over the hearth and the door of the house,—and influence all the concerns of men. To these spirits certain duties are prescribed, and certain oblations offered; the men usually bring wine, the women tea; but these are private ceremonies and heartless duties; the devotion of religion was totally wanting; and in such a state it was not surprising that the doctrines and the practices of the sects of Tao-tse and of Fo should captivate the vulgar, and seduce them to a religion that spoke more strongly to the senses. It would seem, indeed, that the establishment of some popular religion is unavoidable, and that of Fo may, on this ground, be encouraged by the government, though it derives little or no support from it. The ancient religion of China entertained the idea of spiritual beings, but they never clothed them in a corporeal form. In the time of Confucius their temples were without images; their guardian gods and their evil genii were mere imaginary beings, to which they neither gave form or substance; but when the priests of Fo found their entrance into China, they brought with them all the follies and absurdities of the doctrine of Boudh, and grafted them on the superstitions of the Chinese. They filled their temples with all manner of images, each having its peculiar virtues and peculiar influences, and levying for each a tax on the credulity of the people. In some of these temples are not fewer than 300 sainted personages,—monstrous figures as large, and frequently many times larger, than human beings. Their bells and their beads, and burning of incense and tapers,—their images and their altars,—their singing and processions, were well calculated to seduce the populace, who had no outward forms of any religion. So strong was the resemblance of the interior of a temple of Fo,—the dress of the priests,—and the ceremonies of devotion, to those of the church of Rome, that one of the Catholic missionaries says, it seemed as if the devil had run a race with the Jesuits to China, and, having got the start of them, had contrived these things for their mortification.

The Tao-tse are of Chinese origin, and sprung up under the very nose of Confucius, 1500 years nearly before Christ. Their tenets resemble those of Epicurus; they pretend to magic and alchemy,—to consult oracles,—to deal with demons,—and keep old women, who are regarded as a kind of witches. The priests of Fo came from upper India into China, by invitation from a weak emperor, between the 60th and 70th year of the Christian era. Their tenets resemble the Pythagorean. They kill no living animal,—eat no animal food, lest they might partake of a relation or friend, whose soul had taken up its abode in the animal; they believe that the human soul, in its transmigration through an infinity of corporeal existences, becomes purified and perfect, and at length is reunited to the Deity, from whom it originally emanated. They consider the consummation of felicity to consist in the annihilation or total suspension of every faculty of the soul, leaving a void for that of Fo to occupy. Arrived at this stage, the devotee soon dies from exhaustion and want of food; his body is burnt, the ashes put into eight urns,—a tower of nine roofs and eight apartments is built, and an urn placed in each apartment; this is said to have been the origin of the numerous tall pagodas that appear in every part of China. It is pure Shamanism, which may be traced from the Caspian Sea to Japan; from the Saghalien Oula to the Persian Gulf. The priests profess, and many of them are said to practise, the most refined piety,—the most sublime notions of virtue; prayers, fastings, austere and rigorous punishments for the sins of others; chastity, abstinence, penitence, contempt of bodily suffering, to secure for the indestructible soul a better abode in the circle of its transmigrations.

Some of the Catholic missionaries, however, have represented the priests of Fo as living in all manner of vice and luxury; but the testimony of unprejudiced travellers is against them, and even several of the Jesuits speak highly in their favour, saying that, in their moral doctrines, there is little to reprehend; that they inculcate benevolence, humility, reciprocal kindness, command over the passions, and tenderness towards the brute part of the creation. But it may be questioned, whether the priests of Fo or Tao-tse act on any fixed principles. Some of them, for instance, refuse to drink wine, others to eat garlic and onions; some practise celibacy, and profess perpetual continence; others have several wives and concubines. It is quite certain that neither of them are much respected by the government. Their protection or persecution depends on the caprice or feeling of the ruling sovereign. At one time we find their temples demolished, the materials employed for the public buildings,—the bells and brazen statues melted down into money,—and the priest, by an imperial edict, reduced to the rank of the people. One emperor persecutes the Ho-chang of Fo and encourages the Tao-tse; he drinks the beverage of immortality, and dies soon after; his successor eradicates the Tao-tse for poisoning the sovereign, and sanctions the worship of Fo. At present the number of temples dedicated to Fo, and of the priests attached to them, is incalculable. They not only occur in every city, town, and village, but are erected, on a small scale, in private houses, in which priests are employed, though not generally, to instruct the children of the family. One emperor observed, that there were not fewer than 100,000 priests of Fo, and as many priestesses; and that the wisest policy would be to make them marry and get

children for the good of the state; that a religion, which imposed restraint on the natural passions given to man, was undeserving of any regard. No temple can be built without special permission; and they are always used for state purposes by the officers of government, for foreign ambassadors, &c. in their journeying through the country.

The Christian missionaries are exposed to the same capricious conduct; caressed at one time, persecuted at another. One emperor gives them money towards building churches, and the same emperor converts them into public granaries and public schools. In the year 1747, five missionaries were beheaded in Fokien, and two Jesuits strangled in the same year in Kiang-nan; all of which was done according to the law, which says, that the chief of any sect who seduces the people from their duties, under religious pretences, shall be strangled.

The people are ready enough to embrace any of these religions, but the emperor and his court, and all the officers and magistrates, adhere to the ancient religion, as laid down by Confucius, though there is an obvious leaning of the present Tartar dynasty towards that of Fo or Budh, which is that of the Lamas of Thibet. The great temple at Gehol, the summer residence of the Tartar sovereigns now on the throne, is named Poo-ta la (Budh-laya), the residence of Budh; but ostensibly he professes and performs the rites of the ancient religion of China, and, at the appointed times, in the capacity of high priest, testifies his gratitude to heaven by offering up the fruits of the earth, and the flesh of certain animals considered as the most useful, as the horse, the ox, the sheep, the hog, the dog, and the domestic fowl. At such times all labour is suspended,—the public offices and courts of justice are shut up,—and a general festival prevails throughout the whole empire. The vernal ceremony of the emperor holding the plough, is rarely had recourse to in modern times.

The magistrates perform their devotions in the temple or hall dedicated to Confucius; and the usual oblation to his memory is that of a hog, as being the most useful animal known. The ceremonies are performed before a tablet placed on a pedestal, on which is written the name of the philosopher; and at the foot of the pedestal a grave is dug to receive the hair and offals of the animal, that no part of it should fall to unworthy purposes. To this temple every magistrate, on entering upon his office, goes with his official brethren, and, in their presence, after the usual homage to the emperor, professes himself a grateful adherent to the doctrines of the illustrious master, which ceremony amounts to the taking the oaths of fidelity and allegiance to the sovereign. Pere Intorcetta, in his treatise *De Cultu Sinensi*, has translated the whole ceremony from a Chinese author. It is very curious, and bears a marked resemblance to the Catholic ceremony of high mass. They burn incense—pour out libations of wine—chaunt solemn hymns, accompanied with instruments—read aloud a panegyric on his memory—prostrate themselves before the tablet; and then proceed to feast on the oblations, and to drink each of the "cup of felicity." (Intorcetta *de Cultu Sinensi*.)

The common festival of all savage nations is the time of full moon; and the common people of China are still barbarous enough to hold this festival by keeping up a noise and riot the whole night. But the grand festival in which all China partakes is that of the New Year, when families visit each other, exchange mutual compliments and presents, abstain from all labour for several days; and every Chinese, however poor, contrives at this time to treat himself and his family with new dresses. His house is newly painted, and tablets of paper, variously shaped, adorn the walls of his apartments. On new year's day, every Chinese strictly watches his own conduct, and everything that befalls him, being persuaded that whatever he does on that day will influence his conduct during the whole year. An universal holiday prevails—all labour is suspended—and nothing but feasting, rejoicing, music, and firing of crackers, prevail, from the midnight preceding the first day of their new year to the ninth day following. During this period, all is joy and festivity; yet, in this general scene of mirth and conviviality, to the credit of the Chinese it ought to be noticed, that instances of intemperance or inebriety rarely occur.

The festival of the new year is followed by another of a similar kind, which is called the festival of the lanterns. It commences two days before, and continues two days after the first full moon of the new year. All China is then in a blaze. Every house and every village, all the shipping on the canals and rivers, every Chinese, however poor, contrives to light up his painted lantern on these days. Transparencies in the shapes of birds, beasts, fishes, and all kinds of animals, are seen darting through the air, and contending with each other; some with squibs in their mouths, breathing fire, and others with crackers in their tails; some sending out sky-rockets, and others rising into pyramids of party-coloured fire; and others again bursting like a mine with violent explosions. A Chinese knows not why, nor makes any inquiries wherefore these things are. It is an ancient custom, and that is enough for him. The inscriptions on these lanterns would seem to point out its religious origin. The most common runs thus, *Tien-tee San-sheai*, *Van-lin*, *Chin-tsai*, "Oh heaven, earth, the three limits, and thousand intelligences, hail!" (Barrow's *Travels in China*.—Macartney's *Journal*.—Du Halde and Grozier.)

The basis, however, of the ancient Chinese religion, and which forms, as it were, the link which connects it with the government, is the obedience which children owe to their parents, the respect which is due from the young to the aged, and from the living to the dead, in the strict observance of which all other virtues are concentrated; for these are not to be considered as moral duties only, but political and religious ordinances. Every family of condition endeavours to build a temple to the memory of its ancestors; and all persons, not lost to every sense of duty and devotion, visit the tombs of their parents on a certain day in the spring of the year. Never were institutions more innocent in their intention, more blameless in practice, more amiable in their object, or better calculated to produce beneficial results, by recalling pleasing recollections, subduing the passions, and bringing the mind to that

calm and tranquil state to which the memory of departed parents usually disposes it. The love and tenderness of departed parents are among the best impressions of the human mind; "Bind them," says Solomon, "continually about thine heart;" yet the bigotted Dominicans quarrelled with the Jesuits for allowing their Neophytes to honour the memory of departed relations. They represented it as a crime to pluck away the grass and weeds that might have grown around a parent's tomb, and to scatter flowers on a relation's grave; to meet together, and regale themselves with those dainties of which the deceased would have been partaker if alive; fulfilling thus the precept of Confucius, which inculcates the same respect to the dead as if they were living. To support his parents while alive, to bury them decently when dead, to visit their graves at the appointed time, are three indispensable duties of a pious son, by which he proves his gratitude, his sorrow, and his veneration.

There are few families of which some member, in a series of years, has not risen to rank and fortune. Such a one is particularly careful, in obedience to the precept in the ancient book of rites (*Lee-kee*), before he builds a palace, to erect a temple to the memory of his ancestors. To this temple, at particular seasons, all the branches of the family repair together, old and young, rich and poor, high and low—the first officer in the state and the day-labourer. Here all distinction for the time is laid aside, save that of age, which is always reverenced; and he, over whose head has passed the greatest number of years, takes the precedence in making the oblations, and at the subsequent entertainment given at the expence of the more wealthy members of the family. From five to ten thousand persons sometimes meet together on such occasions.

Whether it be the effect of superstition, or of real feeling, or considered as a religious duty, no people observe so much external attention to the memory of the dead as the Chinese. They even move their coffins from the place they have been interred, if the situation be gloomy or the ground swampy. Everywhere in China may coffins be seen exposed on the surface of the ground, because the surviving relation has not been able to fix upon a propitious spot to raise the tomb for its reception. These coffins are generally made of wood sufficiently thick to plank a first-rate man of war. A Chinese usually keeps his coffin by him in the house as a piece of furniture. He contemplates with pleasure the *angusta domus* which is to receive his last remains; and he tries it on just as he would try on a new coat. They believe in a future state of rewards and punishments, but their notions on this head are so vague and mixed up with those of the Boudhists and Brahmins, that it is difficult to say what were the precise tenets of the ancient sages respecting a future state of existence.

Among the religious superstitions of the Chinese, partly native and partly exotic, may be ranked the almost universal observance of lucky and unlucky days, which are duly registered in the imperial kalendar. No marriages, no funerals, no contracts, in short, nothing of importance, must be undertaken on an unlucky day. Even his Imperial Majesty must be governed in his movements by the Board of Astronomers. Another universal superstition is the *fung-shui*, *wind* and *water*, which relates to the exact line in which the roof of a house must be placed, in order to preserve its own security and its owner's prosperity. The Chinese conceive that a peculiar virtue resides in the odd numbers; thus they reckon *three* powers—heaven, earth, and man; *three* lights—the sun, moon, and stars; the *three* relations—a prince and his ministers—a father and son—a husband and wife. *Fo* has his *three* precious ones, and the *Tao-tse* their *three* pure ones, in which the Jesuits discovered the Holy Trinity. The temples of these sectaries have *three* quadrangular courts, the buildings around which contain the *three* classes of spirits, celestial, terrestrial, and infernal. They reckon *seven* ruling powers—the sun, moon, and five planets; *nine* is as efficient and mysterious a number as among the Hindoos; but *five* appears to be the number which is supposed to exert the most extensive influence. The *five* great virtues often spoken of in the ancient classical books are *charity*, *justice*, *good manners*, *prudence*, and *fidelity*. They reckon *five* domestic spirits; *five* elements; *five* primitive colours; *five* seasons of the year, over which are *five* presiding spirits; *five* planets; *five* points of the compass; *five* sorts of earth; *five* precious stones; *five* degrees of punishment; *five* kinds of dress, &c. (*Hist. Gen. de la China.—Mem. Chin.* Intorcetta *de Cultu.*—Morrison's *Dict. &c.*)

Language.

It is perhaps impossible for the Chinese themselves to determine what portion of their present mixed religion and superstitions belong to their ancient institutions, and what has been borrowed from other people. This, however, is not the case with their language: their speech and the character in which it is written, have maintained their primitive purity, and may be considered as exclusively their own. This language, more than any thing besides, stamps them as an original people. It has no resemblance whatsoever to any other language, living or dead, ancient or modern. It has neither borrowed nor lent any thing to any other nation or people, now in existence, excepting to those who are unquestionably of Chinese origin. The written character is just now as distinct from any alphabetical arrangement, as it was some thousands of years ago; and the spoken language has not proceeded a single step beyond the original meagre and inflexible monosyllable. Our countrymen have at length fathomed this hitherto mysterious, and, as it was supposed, unattainable language, the acquirement of which had long set at defiance all the talents and industry of foreigners, and was said to employ the whole lifetime of the natives; to them it is owing that we are now able to give some intelligible account of it. In fact, those insurmountable difficulties turn out to be altogether visionary. The laudable industry of Dr Marshman and Mr Morrison has supplied us with grammars and dictionaries of this singular language. They have not only placed the treasures within our reach, but given us the key to unlock them, though in an uncouth and unsystematic manner,—a defect which, however, is likely to be soon remedied by Mr Manning. As the subject is almost new in this country,

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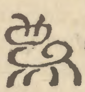
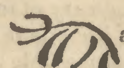
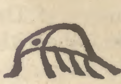
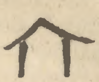
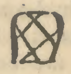
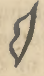
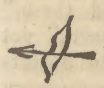
we shall endeavour to give as concise and comprehensive a view of it as our limits will admit, and such as may not only convey a correct notion of the singular nature and construction of the written character, but may be of some use to those who shall engage in the study of it.

The philologists of China speak of knotted cords, twisted from the inner bark of trees, being made use of originally to register events; but as this period is carried back to the fabulous part of their history, it only deserves notice from the remarkable coincidence of a nation having been discovered, many thousand years afterwards, on a different continent, and the antipodes almost of China, who were actually in the practice of using the same means for the same purpose. The second step towards the formation of a written character, by the invention of the *quoa* or digrams of Fo-he, is perhaps entitled to as little consideration as the knotted cords. As a language they must have been too complicated, and the supposed use of them too refined, for a people in so rude a state as the Chinese represented themselves to have been in the time of that chief. It is generally thought, that the written character was first suggested in the reign of Hoang-tee, the third from Fo-he, and that the figures on a tortoise back first gave the idea. Mr Morrison says, that a person named Paou-she, who lived about the year of the world 2900, is considered as the father of letters, and that nine-tenths of his characters were hieroglyphic; he means to say, rude representations of the thing signified, which, in point of fact, may be considered as the first attempt of all uncivilized people to express their ideas to the eye. At a later period, we find several accounts of alterations and new suggestions in the characters, one making them to imitate the lines of the dragon, another the flowing lines of worms and snakes, a third the prints of birds' feet, a forth of leaves, branches, roots, &c. all of which would appear to be nothing more than so many attempts to reduce the rude figures of objects to a more convenient and systematic form for general utility. Enough still remains on ancient seals, and vases for sacred purposes, to show the original state, or nearly so, of the Chinese characters, and to trace the changes that have taken place from the *picture* to the present *symbol*. These ancient characters are to be met with in numerous Chinese books, and a collection of them is contained in Pere Amiot's *Lettre de Pekin*, from which the following are extracted. They are called the *Kou-wen*, and are the most ancient characters that are known:

 a dragon.  a lion.  an ox.

 an elephant.  a tortoise.

 a fish.  a house.  a branch of a tree.  a window.  a bow.

 to shoot. A multitude of similar description is to be found in books of philology, being obviously the rude representations of the several objects they are meant to express.

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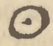
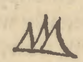
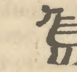
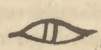
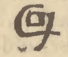
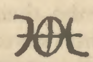
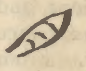
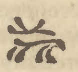
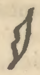
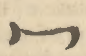
From these rude imitations of objects Chinese writers trace the progressive steps to a more abbreviated and convenient form: thus,  the sun, is now 月.  the moon, 月.  a mountain, now 山.  mouth, 口. 田 a field, now 田.  a horse, now 馬.  the eye, now 月.  the ear, now 耳.  a chariot, now 車.  a boat, now 舟.  a sheep, now 羊.  a bow, now 弓. the dragon is still the complicated character 龍, and the tortoise 龜.

The qualities of objects could only be marked down by arbitrary signs or symbols, which, however, when once settled by convention, were equally expressive with the pictural resemblances of those objects. Many modifications, however, such, for example, as crooked, straight, above, below, great, little, &c. were capable of being expressed to the eye by particular characters, appropriate to their modifications 一 one, 二 two, 三 three,  hooked,  covered, sheltered, protected, &c. but symbolical representations of this kind could not be sufficiently numerous to embrace all the qualities and modifications of objects.

The first attempt at a regular system of classifica-

tion of the characters, which the Chinese had invented for expressing their ideas, is stated to have been that of dividing them into nine classes, called the *Lee-shoo*, and afterwards into six, called the *Lieou-ye*.

1*st* Class, contained all those which had been reduced from the rude picture of the object to a more simple form, as the sun, moon, a man, a horse, &c.

2*d*, Those which pointed out some property belonging to the object, as great, small, above, below, &c.

3*d*, The combination of two or more simple objects or ideas to produce a third, resulting from their union.

4*th*, Those whose names, when sounded, were supposed to imitate the sound of the objects expressed by them.

5*th*, Those which give an inversion of the meaning by inverting the character; and all those used in a metaphorical sense.

6*th*, This class seems to include all those characters that are merely arbitrary, and which cannot be brought under any of the preceding divisions. We shall explain these classes by examples.

This ill-digested and obscure arrangement was soon abandoned for another not much better,—that of classing the characters according to their sounds or names. As these names were all monosyllables, and as each monosyllable began with a consonant, with very few exceptions, and ended with a vowel or liquid consonant, the number of such monosyllables was necessarily very limited; by our alphabet, the whole of them might be expressed in about 330 syllables; but as necessity taught the Chinese to employ in early life the organs of speech and hearing, in acquiring a greater nicety than most nations have any occasion for, they were able to swell the number of their monosyllables, by means of intonations and accentuations, to about 1200 or 1300. As soon, therefore, as the number of characters exceeded the number of words, it is evident that any *verbal* arrangement must be attended with uncertainty and confusion; if, for instance, they had 10,000 characters and only 1250 words, the same word must be applied to eight different characters; and as the latter now, in Kaung-he's Dictionary, exceeds 40,000, each syllable in the Chinese language must, on an average, represent thirty-two different characters; and, in point of fact, there are syllables that give the same name to sixty or eighty different characters.

It is difficult to conceive, therefore, without the assistance of an alphabet, how they could possibly contrive to class the characters in a dictionary according to their *names*, and by what means they could ascertain the name of a character which speaks only to the eye. To discover this, they seem to have had recourse to three different methods; the first was to place at the head of a list of characters, having the same sounds, some common well known character, and to mark them severally with their respective intonations; the second method was that which is still used in all their dictionaries. It consists in writing after the character, whose sound is sought for, two common characters, of which the initial sound of the first added to the final sound of the latter, produces a third; as from the *m* of *moo* and the *ing* of *tsing*, is compounded the third or new monosyllable *ming*; and, in the same way, from *ting* and *ke*, would be formed *te*, &c. The two characters, so employed, are called *tse-moo* or "mother characters," and the third produced from them *tsé*, or "the child." The third method was, by means of a modified Sanscrit alphabet, or series of sounds, which was introduced into China since the Christian era, by some priests of Budh, "to give currency," says one writer, "to the books of Fo." This system is described in the introduction to Kaung-he's Dictionary, though it is never used, and but very little understood. The Chinese, indeed, reprobate the idea of changing their beautiful characters for foreign systems, unknown to their forefathers. "It appears to me," says one of their writers, "that the people of *Tsan* (Thibet, from whence they derived the system of initials and finals) distinguish sounds; and with them the stress is laid on the sounds, not on the letters. Chinese distinguish the characters, and lay the stress on the characters, not on the sounds; hence in the language of *Tsan*, there is an endless variety of sound; with the Chinese, there is an endless variety of the character. In *Tsan*, the principles of sound excite an admiration, but the letters are destitute of beauty; in China, the characters are capable of ever-varying intelligible modifications, but the sounds are not possessed of nice and minute distinctions. The people of Tsan prefer the sounds, and what they obtain enters the ear; the Chinese prefer the beautiful character, and what they obtain enters the eye;" and the Chinese are right; for, unless with their character they gave up their monosyllables, they might almost as well have no written language at all; as, if written alphabetically, it would be wholly unintelligible. The written character assists their meagre monosyllables,—an alphabet would completely destroy them. The written character, however, has probably been the means of fixing the spoken language in its primitive monosyllabic form, as the least change or inflexion of the spoken language, must at once and for ever destroy the connection between it and the written character; and this connection, by the way, is no mean proof of the antiquity of the present symbols. (Pref. to Morrison's *Dictionary*.—Barrow's *Travels in China*.)

These symbols are now reduced to a regular and complete system, which renders the study of the language comparatively easy. A certain number of characters have been selected, which the Chinese call *Tse-poo*, "superintending or directing characters." and sometimes *Shoo-moo*, or the "Eyes of the Book," which, considering them as composing an index to the book, is no bad name. The Jesuits have given them the name of *keys*, and sometimes *elements* or *radicals*, there being no character in the whole language, into the composition of which some one or other of them do not enter. This number, according to the classification now in general use, consists of two hundred and fourteen, and they are divided into seventeen chapters or classes; beginning with those keys or elements that are composed or formed of *one* stroke of the pencil, and ending

with those (of which there is only one) composed of seventeen strokes. Plates LIV. LV. LVI. comprehend the whole of these keys or elements, with their several names and significations. When these two hundred and fourteen keys or elements are once become familiar to the eye, there is no great difficulty in detecting them in any of the characters into which they may enter, and without some one or more of which, no character can be formed. They will be found to stand more frequently on the left side than on any other part of the character, though they also take their stations sometimes on the right, sometimes in the middle, frequently at the top, and occasionally at the bottom; but a little practice and a ready knowledge of these keys, will point them out at once. Thus, in

1. 便 *peen*, " convenient," the key 亻 *jin*, "man" is on the left.

2. 助 *tsoo*, " to assist," has the key 力 *lee* on the right.

3. 全 *tseun*, " the whole," has the key 入 *joo*, at the top.

4. 兵 *ping*, " a soldier," has the key 八 *pa* at the bottom.

5. 愛 *gai*, " to love," has its key 心 *sin*, in the middle of the compound.

The dictionaries are divided into seventeen sections, headed respectively by the seventeen classes or keys, commencing with that class which has its keys of one stroke, and ending with that which is composed of seventeen strokes. The characters which each key governs, or to which it serves as the index, are also divided into classes, according to the number of strokes they contain, beginning at *one*, and proceeding regularly to the greatest number that any one is found to contain, *exclusive of the key;* and this number, together with the key character, being marked at the top of every page in the dictionary, afford a clue by which any character in the language may be turned to immediately, having first ascertained the *key*, and the number of strokes in the remaining part of that character. Thus in the above examples, the character *peen* will be found under the key *jin* and, in the *seventh* section, there being *seven* strokes exclusive of the key; in the second, under the *fifth* section of the index *lee;* the third, under the *fourth* section of the index *joo;* the fourth under the *fifth* section of the key *pa;* and the fifth under the *ninth* section of the index *sin.*

This classification of the characters is extremely simple and easy; the chief object of it would appear indeed, to be like the Linnæan system, that of giving facility to the finding in the dictionary the character that may be wanted. The nature of Chinese symbols admitted, however, of a more beautiful, perfect, and philosophical arrangement, and might, indeed, have been made the most rational and complete system of pasigraphy or universal character, that has yet been attempted. It would seem, indeed, that the Chinese had this idea once in view, but, either through ignorance, pride, or caprice, they have entirely marred the plan, and nearly lost sight of it altogether. In the original adoption of the *shoo-moo*, or " book's eyes" (the *poo* or keys), they selected no less than 479 to serve as indices to the characters, the whole of which were marshalled under nine divisions. The *first* had a few only, consisting of a single line. The *second* embraced celestial objects, as the sky or firmament, the sun, moon, stars, clouds, rain, thunder, &c. The *third*, terrestrial objects, as earth, water, metals, hills, rivers, &c.; the *fourth*, man, and all the animal functions; the *fifth*, moving things, including all the rest of the animal creation; the *sixth*, the vegetable world; the *seventh*, productions of art and human industry; the *eighth*, miscellaneous; and *ninth*, characters of a doubtful genus, whose classification could not well be ascertained. Though this was a complicated, and in some degree an arbitrary classification, yet it comprehends a principle that, if it had been adhered to in simplifying the arrangement of the characters, the Chinese might have challenged the world to produce so beautiful and so philosophical a language as their own. This system, called the *Leu-shoo*, is that stated by Mr Morrison to have been invented by *Paou-she*.

After this the 479 keys or elementary characters were reduced to 214, and the characters themselves arranged under six divisions, as before-mentioned, the nature of which will be best explained by a few examples to each; they will tend to show how much more might have been accomplished in this practical approach to an universal character.

1st Class. The rude representation of the object may now be considered as no longer to exist, but this class consists generally of simple characters, and almost all the great objects of nature are found among the keys or elements which enter into their composition; this may be called the Imitative Class.

2d Class. Under which are comprehended those characters which point out the quality or property of an object, as 上 *shang*, above 下 *shea*, below.

Thus also 一 *ye*, one, is used to represent unity, concord, &c. 丨 *kuan*, straight, upright; 亅 *qúay*, hooked, and generally such characters whose meaning can be extended, in a metaphorical sense, as far as the object represented would admit of being so applied, as, for instance, a line drawn through a square thus, 中 signifies *middle*, or any thing divided into two

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parts; the same character, in a figurative sense, expresses moral rectitude, good dispositions, &c. This class may therefore be called the figurative.

3d Class. Under this class might have been ranked all those compound characters which, if the numbers were properly selected, would have given that peculiar beauty and expression to the language which, even in its clumsy and imperfect state, the Chinese still pretend to feel, by employing significant characters, each of which should be connected with the idea to be conveyed by their union. One half of the language, at least, might thus have been composed, and presented a series of symbols, every one of which would have been intelligible to the eye; whereas not one-sixth part at the most, some say not one-tenth, of the compounds, have any relation to their component parts. A few examples will serve to show how much might have been done by attending to a philosophical composition of the compounded characters. Thus,

亻 *jin*, man, and 言 *yen*, word, forms the compound 信 *sin*, sincere: 日 *je*, the sun, and 月 *yué*, the moon, 明 *ming*, splendour: 中 *tchung*, middle, and 心 *sin*, heart, 忠 fidelity: 亻 *jin*, man, and 田 *tien*, a field, 佃 *tien*, a farmer: 田 *tien*, a field, and 力 *lee*, strength, 男 *nan*, male kind: 耳 *eul*, the ear, and 止 *tchei*, to stop, 耻 *chee*, shame: 口 *koo*, mouth, and 金 *kin*, gold, 唫 *kin*, volubility of speech: 言 *yen*, word, and 寺 *shee*, temple, 詩 *shee*, verses, poetry: 分 *fen*, to divide, and 貝 *pei*, riches, 貧 *pin*, poverty: 囗 *yu*, an enclosure, and 人 man, 囚 *cheu*, a prisoner: 禾 *ho*, rice, and 口 *koo*, mouth, 和 comfort: 一 *ye*, one, and 大 *ta*, great, 天 *tien*, heaven or God: 竹 *tcheou*, a bamboo, and 卩 a slap, 節 *chee*, to govern: 喬 *keu*, high, and 馬 *ma*, horse, 驕 *kheu*, proud.

4th Class. The characters arranged under this class are such as embrace both the *meaning* of the object and the *sound* it is supposed to utter; and it includes objects animate and inanimate. The characters are all compounded of one of the elements to express the genus, added to one imitative of the sound uttered by the object. Thus 氵 *shuee*, water, added to 工 *koong*, forms the character 江 *kyang*, which denotes a rapid stream, expressive, as they say, of water rushing with violence; and 可 *ho*, a river with 氵 *shuee*, water, makes the compound 河 *ho*, a river, the name of which is said to imitate the sound. To this class may also be added those objects in the animal kingdom whose generic character can be expressed by one of the elements, and the species by some other character that shall convey its name merely by the sound of the latter character. If, for instance, to the generic character, *bird*, be added another character whose name or sound is *go*, the new compound will also be named *go*, and will signify a goose; if, to the same character *bird* be added another named *ya*, the compound will also be *ya*, and will signify a *duck*; if. to the generic character *tree*, be added the appellative *pe*, the compound will be named *pe*, and signify a cypress; with *tao*, it will be called *tao*, and signify a walnut tree; and with *lieou*, it will retain the name of *lieou*, and signify a willow. In this class may also be comprehended all foreign names written in the Chinese characters, to which, in order to mark them as destitute of meaning, they usually annex on the left side the character signifying *mouth*. Thus the English word *strong* would require three

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characters, *se-te-lung*, and, with the *mouth* prefixed, would be written thus 吐 *se* 嘚 *te* 嚨 *lung;* but these characters, if the *mouth* was taken away, would be read by a Chinese—the *magistrate procured a dragon.*

5th Class. Consists of an inversion of the sense by an inversion of the whole or some part of the character; or it alters the meaning by giving a different name to the same character; or, lastly, the characters which compose it are used in a figurative or metaphorical sense. An European cannot readily comprehend the illusions or allegories that are frequently contained in a single character, though probably they are not more numerous than those which are found in any of the languages of Europe, rendered easy, and indeed not perceived, by early habit. The combined characters of the *sun* and *moon*, which, in a physical sense, expressed brightness, brilliancy, splendour, are also, in a moral or metaphorical sense, noble, illustrious, famous. The characters *heart* and *dead* form a third, which signifies *forgetfulness: fickleness* or *levity* is represented by a *girl* and *thought; attention*, by the *heart* and *totality; antiquity*, by *mouth* and the numeral *ten;* to *flatter*, is compounded of *word* and *to lick;* to *boast*, of a *mountain* and to *speak*. The *wife of a magistrate* is used metaphorically for *an accomplished lady;* a *wild boar* for *courage;* and a *tiger* for *ferocity*, &c.

6th Class. These characters are either arbitrary, or formed out of some distant or local allusion, most of which are inexplicable to the Chinese themselves. Thus, a *bamboo* and *heaven* form a compound, which signifies *to laugh; water* and to *go*, compose a character signifying *law; wood* and the *sun* form the word *east;* the character *woman* three times repeated may signify *adultery*, or *communicating with an enemy*. These may or may not be arbitrary combinations. We can explain why the compound of *wine* and *seal* should signify *marriage*, from the circumstance of *wine* being presented by the bridegroom to the bride as the *seal* to the contract; and why that of *girl* and *upright* should signify *concubine*, or inferior wife, because such a one must *stand* in the presence of her lord and master; also, why that of *woman* and *sickness* should signify *death*, because when the sovereign was sick, and given over by the physicians, he was left to *die* in the hands of *women;* but by far the greater part are utterly inexplicable.

Such, by the Chinese account, is the philosophy of their language; not very clear, it must be confessed, nor exactly calculated for practical facility; but, at the same time, approximating to a very beautiful system. That system has, to a certain degree, been preserved in the modern classification under the 214 elements. Thus, under the element or key which signifies *heart*, we shall find all the characters arranged expressive of the sentiments, passions, and affections of the mind, as grief, joy, love, hatred, anger, &c. The element *water* enters into all the compounds which relate to the sea, rivers, lakes, swamps, depth, transparency, &c. The key or element *plant*, takes in the whole vegetable kingdom. *Yen*, a *word*, enters into the composition of those characters which relate to reading, speaking, studying, debating, consulting, trusting, &c. All the handicraft trades, laborious employments, and a great number of verbs of action, have the element *hand* for their governing character. All this is perfectly intelligible; but, on casting a glance over the elementary characters, it will be seen that fully one half of them are utterly incapable of being formed into any generic arrangement; and one is surprised and puzzled to conjecture by what accident they could possibly have been included among the elementary characters, or even as indices to characters. The fact is, that, of the 214 characters thus employed, not more than 150 can be considered as effective; the rest being very rarely employed in the combination of characters. Of the 40,000 characters, or thereabouts, contained in the standard dictionary of the language, 60 of the elements govern no less than 25,000. The most prolific is the element *grass* or *plants* (No. 140), which presides over 1423 characters; the next *water* (No. 85), which has 1333; then the *hand* (No. 64), which has 1012. After these follow, in succession, the *mouth*, *heart*, and *insect*, each having about 900; then a *word*, a *man*, and *metal*, each exceeding 700; next a *reed* or *bamboo*, a *woman*, *silk*, a *bird*, *flesh*, *mountain*, &c., each governing from 500 to 600, &c. In the modern classification, therefore, of the characters, though probably intended as a more convenient instrument for reference in the dictionaries, so much of the natural arrangement has been preserved as will serve to convey to the eye, at once, the general meaning of a character; at least of such characters as are governed or fall under any of the principal elements. They have even gone beyond this. Feeling how much more capable of nice discrimination the eye is than the ear, the written character has been employed to mark distinctions, which, in an alphabetic language, would be impossible. Instead of the modifications of time, place, age, colour, and the like, by which sensible objects are affected, being expressed by so many epithets or additional characters, in the several stages of their existence, or the lights in which they may be viewed, the Chinese employ only one single character for each several modification of which an object or idea may be susceptible, whether in the physical or intellectual world. Thus they have the key or elementary character for *water* simply; another under that key for *salt water*, a third for *fresh water*, a fourth for *muddy* water, a fifth for *clear* water; and so on for *running*, *standing*, *deep*, *shallow*, and every other qualification that water is capable of receiving; and the same of love, anger, jealousy, ambition, &c.; all of which are expressed by their respective symbols combined with the element *heart*.

The colloquial language is not less singular than the symbolical characters; being, like the latter, exclusively their own; having borrowed nothing from, nor lent anything to, the rest of the world. The 330 monosyllables, each beginning generally with a consonant, and ending with a vowel, or liquid, or the double consonant *ng*, which, as we have observed, complete the catalogue of words in their

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China. language, are, by means of four modifications of sound, or intonation to each syllable, extended to about 1300; beyond which, not one of them is capable of the least degree of inflexion, or change of termination; and the same unchangeable monosyllable acts the part of a noun substantive, and adjective, a verb, and a participle, according to its collocation in a sentence, or the monosyllables with which it is connected. It is neither affected by number, case, nor gender; mood, tense, nor person; all of which, in speaking, are designated by certain affixes or prefixes to mark the sense. Thus the genitive of *love, gai*, is expressed by the particle *tié* set after it, as *gai-tié*, of love; the dative by *eu-gai*, to love; and the ablative by *tung-gai*, by or from love. The plural is expressed sometimes by the repetition of the noun, as *yin*, a man; *yin-yin*, men; *to-yin*, many men; *to-to-yin*, all men. Certain particles of number are also employed before nouns, which vary according to the nature of the noun. Thus *man* has *ko*, as *san-ko-yin*, three men; most other animals *tchee*, as *liang-tchee-ma*, two horses; bodies with extended surfaces *tchiang*, as *ye-tchiang-tchoa*, one table, &c. The number of particles so employed amount to about thirty. The final expletive *tsé* is added to nouns, not only to distinguish them from adjectives, but for the sake of euphony; as *pie-tsé*, a pipe; *fang-tsé*, a house; *ya-tsé*, a chair; the particle *tié*, the same which designates the genitive of the substantive, is set after the adjective or pronoun; as *ta*, he, with *tie* after it, becomes a possessive, *ta-tié*, his, &c. The gender of nouns is seldom necessary to be expressed in conversation, unless for the sake of removing ambiguity. When this is the case, *nan* and *neu* distinguish male from female, as *nan-yin*, a man; *neu-yin*, a woman. Adjectives admit of comparison in various ways. Commonly *ye-yang* is used to express the positive, as *ye-yang-hoa*, as good as, or equally good; the preposition *keng* forms the comparative, as *keng-hao*, better; and, with the addition of *toa* following it, the superlative, as *hao-toa-keng*, the best; a repetition of the positive also marks the superlative, as *hao-hao*, very good.

The personal pronouns *go, ne, ta*, I, thou, he, are made plurals by the addition of *mun*, as *go-mun, ne-mun, tu-mun*, we, ye, they. *Che-ko*, this, and *na-ko*, that, are the demonstratives.

The only tenses of the verb necessary to be distinguished are the present, past, and future. The past is formed by the particle *leau* set after it, and the future by *yau*, will or determination, or *tchong lai*, time to come. Thus *go gai*, I love; *go gai leau*, I have loved, or did love; *go yau gai*, or *go tchang lai gai*, I shall hereafter love. The negatives generally in use are *mo* and *poo*; as *yeu*, to have; *mo yeu*, not to have; *hao* good; *poo hao*, bad.

Such is the simple and inartificial language spoken by a mass of people equal in number to that of the whole of Europe. Its imperfection must be obvious, when it is considered that 40,000 distinct characters are represented by about 1300 monosyllabic sounds; but, as a good composition is intended only to be seen, the particles and expletives, necessary in familiar conversation, are all omitted; if such writing were read aloud, it would scarcely be intelligible, and, at any rate, full of ambiguity. Indeed, it frequently happens, that, in reading a paper, the auditors are assisted by the reader making, with a motion of his hand in the air, or with his fan, the shape of the character, or, at least, the key of it, to remove any ambiguity. This, in conversation, is obviated by the use of certain expletives. For instance, when a man is speaking of his father, which is *foo*, a monosyllable that has seventy or eighty other meanings besides that of father, a Chinese will say *foo-chin*; and, instead of *moo* for mother, *moo-chin*; the syllable *chin*, signifying *kindred*, removes at once all doubt as to the meaning of the speaker; but the *chin*, in writing, is wholly unnecessary, and would be left out; the character signifying *father* being totally different from any other character that may have the name of *foo*. A foreigner, not always aware of this, is liable to many equivoques in speaking the language. Thus a missionary, requesting to be allowed to pass the night at a peasant's house, asked for a *young girl* to sleep with, when he meant only to ask for a *mat*; and another told the Emperor he served *three wives*, when he meant to say so many *churches*. (Barrow's *Travels in China*.—Morrison's *Dictionary*.—Marshman's *Clavis Sinica*.—Fourmont's *Meditationes Sinicæ*, &c.)

Literature. One of the most remarkable features of Chinese policy, is the encouragement given to the cultivation of letters, which are professedly the sole channel of introduction to political advancement in the state, and to the acquirement of office, rank, and honours of almost every description. The pursuits of literature throw open the highest offices in the state to the lowest of the people; and, with a few exceptions of particular favourites, or of Tartars connected by blood with the imperial family, it would appear that honours and offices are generally bestowed according to merit. With the prospect of such rewards, the number of competitors is very great, and a taste for letters is almost universally diffused among all ranks and denominations. Schools abound in every town and village, and the best education that China affords is to be had on the most moderate terms. In every part of the empire, certain magistrates are appointed by the government to call before them all candidates for employment, to direct them in their studies, and twice a year to hold public examinations, when small presents are distributed to the most deserving. As a farther encouragement to literature, the press is left free to all, and any one may print what he pleases, taking his chance for the consequences. That this unrestrained liberty of the press should exist in one of the most arbitrary governments that is known, is a remarkable phenomenon in the history of nations. No previous licence is required; no restrictions are imposed; though the publication of books is made amenable to certain regulations established by law. In general, crimes, and their corresponding punishments, are clearly and minutely defined in the *Laws of China*, but the law which regards the press is left, perhaps intentionally, vague and uncertain. According to the *Leu-tee*, "Whoever is guilty of editing wicked and corrupt books, with the view of misleading the people; and whoever attempts to excite sedition by letters or hand-

bills, shall suffer death by being beheaded; the principals shall be executed immediately after conviction, but the accessaries shall be reserved for execution at the usual season." And further, "All persons who are convicted of printing, distributing, or singing in the streets, such disorderly and seditious compositions, shall be punishable as accessaries."

These severe laws are by no means a dead letter; numbers have been executed in virtue of them. Three unfortunate authors were punished with death, and their families banished, by that great patron of literature, Kien-lung, in three consecutive years, for publishing books that no European government would have deigned to notice; but political discussions are least of all palatable to despotic governments, and are easily brought under the charge of constructive treason,—a crime that in China is never pardoned.

The instances, however, that occur of severity of punishment, seem to have little effect in diminishing the number of publications, and are not more hostile to the liberty of the press in China, than the occasional punishment of a jail, for libel, is destructive of that liberty in England. A writer in a popular periodical journal says, that thousands of novels and moral tales, amusing stories, laughable comedies, moral precepts from ancient sages, and exhortations from living sovereigns; popular songs, fables, and romances; books of receipts to heal the sick and to pamper the appetite; predictions of the weather, and of good or bad luck; manuals of devotion, of religious rites, and rules of good-breeding; almanacks and court calendars, are the lighter sort of publications which issue daily from the press in Pekin, and other great cities of the empire. All ranks in China read, and find it a cheap luxury; the more bulky and expensive works, as those on history, philology, jurisprudence, &c. are sometimes published by subscription, but are supplied to the libraries of the magistrates by the government. Libraries are seldom formed to any great extent by individuals. The grand collections of history, philosophy, and other standard national works, published by the direction of the sovereign, under the superintendence of the *Han-lin*, are distributed to the princes of the blood, the viceroys of provinces, presidents of departments, and to the learned of the empire, but are rarely met with in the libraries of private individuals.

We can form no estimate of the state of literature in China, from the paraphrastic translations of ill-chosen books, and the commentaries on them, made by the Jesuits and other Catholic missionaries; the trite morality of Cong-foo-tse and Men-tse; the wise sayings of this emperor, and the wicked doings of that, which are contained in the *Ou-king* and the *Se-Choo*, their ancient canonical books, convey no better idea of the state of China or of its literature, than the Domesday Book does of that of England. The *Tong-kien-kang-moo*, or General History of China, by Pere Mailla, may be considered as the most important of missionary translations. Some of the Odes of the *Shee-king*, by Pere Premare, are curious, as exhibiting specimens of their poetry 4000 years ago. The *Eloge de Moukden*, a poem by the Emperor Kien-lung, by Pere Amiot, is no bad specimen of modern poetry, for such it is, though, like Ossian, it is unmeasured poetry. Of the merits of his *Conquest of the Miao-tsé*, by Mr S. Weston, through the medium of a French translation, we are unable to form any just idea. Works on philology, and commentaries on the characters of the languages, are endless; and, on this subject, many curious observations will be found in Pere Amiot's *Lettre de Pekin*, and in various parts of the *Mém. concernant les Chinois*. The little novel of *Hao-kiau-tchuan*, edited by Dr Percy, from the papers of an English supercargo, is so charming a specimen of that kind of writing, as to make us regret that we have not more. The orphan of the house of Tchao was not unworthy of the tragic muse of Voltaire, and yet it was the only specimen of this kind of composition that had appeared in an European dress till the present year. We have now another drama more closely and more faithfully translated by Mr Davis, taken from the same collection of one hundred dramas in which the *Orphan* is found. The *Mémoire sur l'art Militaire*, although collected from the works of the greatest Generals, was unworthy the trouble bestowed upon it by Pere Amiot; the military movements, as there represented, are more suitable for mountebanks, tumblers, and posture-makers, than for soldiers; the Chinese are, in fact, the worst soldiers in the world. The same thing may be observed with regard to his Treatise on Chinese Music, a farrago of trash, not one word of which either he or his Chinese author understood. We have some curious matter on the rites and ceremonies of the several religious sects in China, by Pere Intorcetta and La Favre, and on various subjects in the *Hist. de l'Academie des Inscript. et Belles Lettres*, by Mss. Freret and De Guignes; and especially of books translated into Chinese from the Sanscrit, which are to be found in the temples of Fo. These volumes would, no doubt, throw much light on the state of Hindostan before the Mahommedan irruption, which created such havock and devastation of Hindu literature. It was chiefly with the view of examining these documents, for the better illustration of the history, religion, and literature of India, that Sir William Jones set about learning the Chinese language. De Guignes ascertained, that the priests of Fo were in possession of 5400 volumes on the religion of India in the sixth century of the Christian era. Five centuries before this, another priest translated twenty-three different books on religion into Chinese, which were lodged in the library of the temple of Sei-gan-foo; and, about the same time, one of a party of pilgrims, who travelled from this city to Benares, from thence to Ceylon, and returned by sea to Canton, published a relation of his travels, under the title of *Fo-quo-kee*, a History of the Kingdom of Fo, of which there is a copy in the King's library at Paris. Frequent mention is made in the *Tong-kien-kang-moo*, and other histories of China, of priests being dispatched into India, in the early periods of the Christian era, for the express purpose of procuring Hindu writings, chiefly those on religion and astronomy; from which it may be concluded, that, if the Hindus really had any thing valuable which perished by Mahommedan bigotry, it may still have survived in China.

Among the works of which a translation would be

most desirable, may be mentioned the *Tai-tsing-ye-tung-tsé*, a complete Encyclopædia of Arts and Sciences, in 200 volumes, published under the sanction, and by the authority, of Kien-lung; for, though we have nothing to expect from the state of science in China, they far surpass all Europe in many arts, and are in possession of others of which Europe is entirely ignorant. The *Ta-tsing-hoei-tien*, another work containing the whole Institutes of this vast Empire, with all the regulations of the several departments of government; the whole system of jurisprudence, of revenue, and finance, taxation, &c. would afford an interesting picture of this extraordinary nation. Of this curious work, also published by the authority of Kien-lung, there is a very general abstract by M. Cibot, in the 4th volume of *Mém. sur les Chinois*. This abstract, and the recent translation of the *Ta-tsing-leu-lee*, by Sir George Staunton, enable us to form a tolerably correct notion of the machinery by which the multitudinous population of the largest empire on the face of the earth has been uniformly kept in motion, and performed its several functions for the last four thousand years.

The desiderata of Chinese literature in Europe are some of their lighter productions, which our increasing knowledge of the Chinese language will no doubt soon supply. The dictionary of De Guignes, compiled by the Jesuits, and the more important dictionary of Kang-hee, called the *Tsé-tien*, now under publication in the English language by Mr Morrison, a *Chinese Grammar* by the same gentleman, and the *Clavis Sinica*, ponderous as it is, by Dr Marshman, with various translations of these missionaries, have rendered the study of that language so easy, as to leave no excuse for the continuance of that total ignorance which has, for two centuries nearly, prevailed among the East India Company's servants stationed in China. If any proof were wanting of the possibility of a speedy acquirement of the Chinese language by a foreigner, the circumstance of Mr Davis having translated several Chinese works, both in poetry and prose, may be adduced as an example in point. Before he had been two years in Canton, this gentleman had acquired a sufficient knowledge of the language to enable him, with occasional assistance of a native, to translate several pieces of poetry, two or three novels, and, which is probably most difficult of all, a Chinese drama, which has recently been published in London. Many years ago, Sir George Staunton was able to carry on a correspondence with the officers of government at Canton,—to translate the *Ta-tsing-leu-lee*,—the journal of a Chinese officer through the vast regions of Tartary, by the Baikal Lake, as far as the Kerghis hordes, near the borders of the Caspian, which we hope to see published. It corroborates, we understand, in an extraordinary manner, the observations of Bell, which, indeed, were never called in question; and is the more curious, as they both travelled in the same year, and must have crossed each other on the way. Sir George has, besides, we believe, translated a Chinese drama, and two or three short tales from a collection called *Tsing-tsu*, or "Histories descriptive of the Passions." Mr Manning, whose name we have already noticed, has made himself perfect master of the Chinese language, an account of which he intends to publish. We mention these to show, that there is neither any difficulty in acquiring a knowledge of the Chinese language, nor want of inducement to prosecute the study of it. Sir George Staunton is alone in possession of from 3000 to 4000 volumes.

Europeans have been deceived as to the vast number of characters in this language, which was supposed to create its difficulty. In the great dictionary of Kang-he, there are not more than 40,000 characters, of which about 36,000 only are in use. The lexicon of Scapula contains about 44,000 words; Ainsworth's dictionary 45,000, and Johnson's about the same number. The whole works of Confucius contain only about 3000 different characters. The *Leu-lee* may have, in the whole, about 100,000 characters, but not more than 1860 different ones throughout the whole work. Where, then, can there possibly be any difficulty?

Poetry.

The origin of Chinese poetry is indicated by the component parts of the character employed to express it,—*words* of the *temple*,—short measured sentences, delivered as instructions to the people,—such are those in the ancient writings, and such chiefly are the moral maxims of Confucius. It is so far from being true, as Grozier flippantly asserts, "that a learned man writing good verses, would be considered in the same light as a dragoon officer playing well on the fiddle," that there are few men having any pretensions to learning, who do not write verses. The several odes and didactic poems of Kien-lung, were quite sufficient to make poetry fashionable, if there were no taste for it among the people; but all are fond of poetry. We have before us the translation of part of an Ode on England and London, written by a common Chinese servant, brought over by a gentleman from Canton, in which are many just observations, with accurate and concise descriptions; the climate, he says, is cold, and people live close to fires; that the houses are so lofty that you may pluck the stars. Kang-he made the same observation to the Jesuits, and supposed that Europeans lived like birds in the air, for want of space to build upon. Our Chinese proceeds to say, that the virtuous read their sacred book, and *(pe lee to Got)* pray to God; that they hate the French, and are always fighting with them; that the little girls have red cheeks, and the ladies are fair as the white gem; that husbands and wives love each other; that the playhouses are shut in the day and open at night; that the players are handsome, and their performance delightful, &c. The nature of the character is well adapted to that expressive kind of poetry which pleases the eye of a Chinese, by selecting such as are most comprehensive, or such as allude to some ancient custom, or such as can be used in a metaphorical sense: for instance, "the rushing of water down a precipice, roars like thunder," is expressed by a single character; and that which signifies "happiness," reminds him, by its component parts, of his guardian angel,—of the benefits of union and concord,—of plenty, signified by a mouth over a cultivated field. The intercalary moon is expressed by the character *king* placed in that of

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gate, because on such an occasion it was the ancient custom for the king to stand in the door. Thus, also, a *man* and *word* express *fidelity; fire* and *water*, calamity; *eye* and *water*, tears; *heart*, *truth*, and *words*, *sincerity; word* and *nail*, a *bargain; beauty* and *goodness* are signified by a character composed of a young virgin and an infant; a *flatterer*, of *word* and *to lick;* a kingdom is expressed by a *square* or *space* within which is a *mouth* and *weapons*, alluding, perhaps, to *arms* and *counsel*, being the best protection of a state. But though the sense of seeing seems to be that which is rather addressed in Chinese poetry than the sense of hearing, yet they have their rules both of rhyme, and measure, and quantity, the last of which is given by the tones or accentuations, which are entirely modern. Among the specimens of ancient poetry from the *Shoo-king*, the following is an address of the Emperor *Chun* to his ministers:

Koo, koong khée tsai
Yuen shyeu khée tsai
Puh koong hee tsai.

When the chief ministers delight in their duty,
The sovereign rises to successful exertion,
A multitude of inferior officers ardently co-operating.

To which the ministers responded in the same strain:

Yuen shyeu ming tsai
Koó koong lyang tsai
Shyu tsé khang tsai.

When the sovereign is wise,
The ministers are faithful to their trust,
And all things happily succeed.

The *Shee-King*, or collection of odes, upwards of 300 in number, is of a higher strain, one of which, on marriage, has been beautifully versified by Sir William Jones. The lines consist of no definite number of syllables, some containing three, some seven, but the greater part are limited to four. The rhyme is equally irregular, some having none, in others every line terminating with the same word; sometimes six lines rhyme in a stanza of eight, occasionally four, three, and sometimes only the first and last. Four lines in the stanza, and four characters in each line, seem to be the most common measure in ancient poetry; but many odes of the Shee-king extend the stanza to eight, ten, or twelve lines. At present, *five* and *seven* characters are the most common number in the line; the former having the stanza of sixteen, the latter generally of eight; the rhyme seems to be entirely arbitrary. There is not much sublimity of mind or depth of thought in these odes, but they abound with many touches of nature, and are exceedingly interesting and curious, as showing how little change time has effected in the manners and sentiments of this singular people. A number of rules with regard to the tones have recently been introduced, which would require more space to describe than they seem to deserve. As a didactic poem, the *Eloge de Moukden* of Kien-lung, appears by no means to be destitute of merit; it is considered in the Chinese to be highly poetical, though not written in measured lines; and it contains much beautiful description. His Ode on Tea is of a humbler cast, and some lines on tea-cups, generally ascribed to him, are, in an English dress we have seen, absolute nonsense: the translator has, in fact, mistaken the whole meaning.

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We give the following from Grozier's collection, as no unfavourable specimen of modern poetry. It may be called the Contented Philosopher.

"My palace is a little chamber, thrice my own length; finery never entered it, and neatness never left it. My bed is a mat, and the coverlid a piece of felt; on these I sit by day, and sleep by night. A lamp is on one side, and on the other a pot of perfume. The singing of birds, the rustling of the breeze, the murmuring of a brook, are the only sounds that I hear. My window will shut, and my door open, – but to wise men only; the wicked shun it. I shave not like a priest of Fo; I fast not like the Tao-tsé. Truth dwells in my heart; innocence guides my actions. Without a master, and without a scholar, I waste not my life in dreaming of nothings, and in writing characters, still less in whetting the edge of satire, or in trimming words of praise. I have no views; no projects. Glory has no more charms for me than wealth; and all the pleasures of the world cost me not a single wish. The enjoyment of ease and solitude is my chief concern. Leisure surrounds me, and bustle shuns me. I contemplate the heavens and am fortified. I look on the earth and am comforted. I remain in the world without being in it. One day leads on another, and one year is followed by another; the last will conduct me safe to port, and I shall have lived for myself."

The Drama.

Dramatic entertainments are in China as in Europe closely connected with poetry. The songs and recitative in the lighter pieces, abound with characters of double meaning and equivocal expression; but are generally so contrived, that, while the written characters shall bear one sense, the sound shall convey to the ear another; and these subterfuges are resorted to, in order to avoid that punishment which the magistrates would be compelled to inflict for a breach of the law, respecting public decorum, in the publication or exhibition of any thing directly and unequivocally obscene; and yet real life is represented on the stage without any of its polish or embellishments; all acts, however infamous or horrible, are exhibited on the stage; a murder or an execution. Whether the culprit be condemned to die by the cord, by decollation, by being cut into ten thousand pieces, or by being flead alive, the spectators must be indulged with a sight of the operation. Nor do they stop here. Those functions of animal life, over which decency requires a veil to be thrown, are exhibited in full display; many of them so gross and indelicate, so coarse in the dialogue, and so indecent in the scenic representation, that foreigners who have witnessed them have retired from the theatre in disgust.

It is no excuse that these obscene exhibitions were performed for the amusement of foreigners, whom they are pleased to consider as barbarians; the representation of real life, in its ugliest dress and most hateful deformities, could only be con-

ceived by a people of depraved habits and a vicious taste. Of the Court exhibitions, we have amusing descriptions in the Journals of Lord Macartney, Van Braam, and De Guignes. Lord Macartney describes the theatrical entertainments to consist of great variety, tragical as well as comical; some historical, and others of pure fancy, " partly in recitative, partly in singing, and, partly in plain speaking, without any accompaniment of instrumental music, but abounding in battles, murders, and most of the usual incidents of the drama." The grand pantomime followed, the subject of which his Lordship conceived to be " the Marriage of the Ocean and the Earth. The latter exhibited her various riches and productions, dragons, and elephants, and tigers, and eagles, and ostriches, oaks, and pines, and other trees of different kinds. The ocean was not behind hand, but poured forth on the stage the wealth of his dominions under the figures of whales and dolphins, porpoises and leviathans, and other sea monsters, besides ships, rocks, shells, sponges, and corals, all performed by concealed actors, who were quite perfect in their parts, and performed their characters to admiration." These marine and land productions paraded about for a while, when the whale, waddling forward to the front of the stage, took his station opposite to the Emperor's box, and spouted out of his mouth into the pit several tons of water. " This ejaculation," says his Lordship, " was received with the highest applause, and two or three of the great men at my elbow desired me to take particular notice of it, repeating at the same time *Hac, kung hao! charming, delightful!*" After this, they were entertained with tumbling, wire-dancing, and posture-making; and the amusements of the morning concluded with various fireworks, which were much admired for their novelty, neatness, and ingenious contrivance.

The Dutch ambassadors were chiefly entertained by the feats of jugglers and posture-makers; after which was a kind of pantomimic performance, the principal characters of which were men dressed in skins, and going on all-fours, intended to represent wild beasts; after them were a parcel of boys habited like mandarins, who were to hunt these animals. " This extraordinary chace, and the music and the rope-dancing, put the Emperor into such good humour, that he rewarded the performers very liberally; and the ladies behind some Venetian blinds appeared, from their tittering, to be equally well entertained."

An eclipse happened, which kept the emperor and his mandarins the whole day devoutly praying the gods that the moon might not be eaten up by the great dragon that was hovering about her; and the next day a pantomime was performed, exhibiting the battle of the dragon and the moon, and in which two or three hundred priests, bearing lanterns at the end of long sticks, dancing and capering about, sometimes over the plain, and then over chairs and tables, bore no mean part.

The dramatic representation of the Eclipse of the Moon is thus described by De Guignes: " A number of Chinese, placed at the distance of six feet from one another, now entered, bearing two long dragons of silk or paper painted blue, with white scales, and stuffed with lighted lamps. These two dragons, after saluting the emperor with due respect, moved up and down with great composure; when the moon suddenly made her appearance, upon which they began to run after her. The moon, however, fearlessly placed herself between them; and the two dragons, after surveying her for some time, and concluding apparently that she was too large a morsel for them to swallow, judged it prudent to retire, which they did with the same ceremony as they entered. The moon, elated with her triumph, then withdrew with prodigious gravity, a little flushed however with the chace which she had sustained."

It is not easy to reconcile the admission of these puerile absurdities and gross indelicacies on the stage where regular dramas of a higher order exist, and comedians are trained up to perform them, unless it be that their thorough contempt for foreigners induces them to think anything good enough for their entertainment. The dialogue in the regular drama is uttered in a kind of whining recitative, full of querulous cadences, which are drowned generally in a crash of trumpets, symbols, gongs, and the kettle-drum. The passions, as in the Italian opera, are mostly expressed in song. If a fight ensues, each of the combatants sing a stanza, and then fall to, and, during the combat, the instruments of music keep up a most tremendous noise.

Comedians are not much esteemed, if we may judge from the statute against actresses, and yet it is said that Kien-lung's mother was on the stage; since which, the parts of females are performed by eunuchs and boys, the latter of whom are regularly bound apprentices to the trade. Pekin is said to have about a hundred different companies, and each company to consist of fifty persons and upwards, composed of speakers, musicians, tumblers, and jugglers, so as to suit all tastes. They live in passage-boats, in which they are conveyed from place to place. There are no regular theatres, but players are hired by the wealthy at so much by the day. They are said to be ready at any moment to perform any play that may be fixed upon, out of a list seldom short of 100. These are the sort of plays performed before their countrymen, and not the trash which they exhibit before foreigners at the Court and at the sea-port town of Canton. The translation of *An Heir in his Old Age*, by Mr Davis, is calculated to give rather a favourable opinion of the Chinese drama. It consists of five regular acts; it has plot and character; the action is simply one, and never stands still. It is deficient in wit, but not in sentiment, and the several characters are well preserved. It is, in short, a story that may commonly occur in a family, thrown into action instead of being merely told, and the catastrophe is quietly and naturally brought about.

Many of their dramas, however, are full of bustle and business, and abound with incident. They are generally representations of real life, and contain sometimes the whole life and adventures of an individual,—some great sovereign, or celebrated general,—a history in fact thrown into action, not unlike that " Lamentable tragedy, mixed full of pleasant mirth,

conteyning the life of Cambyses king of Percia, from the beginning of his kingdom unto his death." The argument of a drama of this kind was found among Mr Wilkinson's papers. An aged matron and her son (the hero of the piece) being reduced to poverty, are driven to the necessity of asking alms for their support. An officer's daughter, finding them of good parentage and education, gives money to the son, and engages the mother to attend on her. The son hires himself to serve in a tea-house kept by an old woman and her daughter. A rakish young officer, liking the daughter, gains the consent of the old woman to take her into his house, but the girl rejects the offer. He then sends his servants to carry her off by force, but the new servant rescues her. The officer lays an accusation against him; he is carried before a magistrate, who orders him a flogging, and to wear the cangue or wooden collar. Not satisfied with this, the young officer sends out his people with cudgels to beat him to death. Unable, on account of the collar, to reach his mouth, they find the young girl giving him food. His hands, however, being at liberty, he lays about him on all sides, and, by a sudden whirl of his wooden ruff, the corner of it strikes the young officer on the head, and kills him on the spot. The head-man of the street takes him and the young woman into custody, carries them before a magistrate, who releases the young man, but takes the girl of the tea-shop into his own house, from which she is suffered to elope by his wife. The superior magistrate of the district being informed of the death of the young officer, and that the girl of the tea-house was the chief cause of it, sends an order to the inferior magistrate, who had taken her into his house, to deliver her up; she is nowhere to be found; and, in the greatest dismay, this inferior magistrate orders his servants to go out and seize any woman they meet with, and carry her before the superior magistrate. They find, in a temple, the officer's daughter first-mentioned, with the old woman, who had fled from home on her father being disgraced, and all his goods and family seized. She is hurried away before the magistrate, and (in the supposition of her being the tea-house girl) sentenced to lose her head. Being carried to the place of execution at midnight, she is recognised by the old matron's son, who was among the spectators, and who, by seizing the officer's sword, attacks the executioner, and rescues the young lady; but they are speedily taken, and both ordered for execution; the truth, however, is discovered, and the magistrate who played off the trick suffers in their stead. This superior magistrate, however, falls in love with the lady, and proposes to take her for his *first* or legitimate wife, and hires the young man for his servant. The lady peremptorily refuses, upon which she is ordered to be beaten by the servants till she lies for dead, and the young man is directed to carry the body and throw it into the river. He lays her on the bank, covers her with his cloak, and goes to buy a coffin, as his last act of gratitude for one who had relieved his mother and himself in their distress. A boat approaching, and finding it a woman, carries her off to serve the Tartar queen in her wars against the Chinese; this same people, it seems, having already carried off the old matron and the young girl of the tea-shop. Our hero returning, and missing the body, was in great distress. However, he tells his master he has obeyed his commands, who by this time had learned whose daughter he had thus cruelly treated; and, to prevent farther mischief, he engages his new servant (the hero of the piece) to put to death her father; instead of which he reveals the whole to the father, and they concert together and put to death his master. The hero then flies to the wars against the Tartars; and it being the custom (or the Chinese thinking so) for the women to fight, he encounters his own mother, the young lady who relieved her, and the girl of the tea-shop, on which discovery he suffers himself to be taken prisoner by the Tartars, is brought before the queen, who, on hearing the story, sets the three Chinese women at liberty, and commits them to his care. They all return into China; they find the father of the young lady restored to his rank and honours, who bestows his daughter on the hero of the piece; and the other young woman of the tea-shop is provided for by his taking her for a second wife. By the Emperor's patent, he is created a great mandarin, for the service he has performed, receives the suitable habits for himself and his two wives, and the congratulations of all their friends.—(Macartney.—Staunton.—Barrow.—De Guignes.—*Missionary Communications* in Du Halde, Grozier, *Mem. sur le Chinois, &c.*)

Music. As connected with the drama, the state of Chinese music may next be considered. Detestable as Europeans must find the very best of this music, such is the force of habit or prejudice, that the Chinese are as fond of their own as a Highlander of the bagpipe. Their ancient writers ascribe to it all those extraordinary and extravagant effects of softening the manners and promoting civilization, taming wild beasts, moving rocks and stones, and, in short, performing all the wonders which have been related of the strains of Orpheus and the lyre of Amphion. The Shoo-king says, that the Emperor *Chun* considered music as one of the most efficient engines of government, and a test for proving the national character. Confucius was so astounded with one of the old airs, that he could neither eat nor drink, and for three months could think of nothing else. In the book of *Odes*, it is remarked, that, while the Institutes of the empire continue to be observed, and music to be cultivated, China will remain a mighty and invincible nation; and one of the early emperors has this remark: "Would you conquer your enemies without bloodshed, diffuse among them songs set to tender and voluptuous melodies, to soften their minds and enervate their bodies, and then, by sending among them plenty of women, your conquest will be complete."

Dr Burney has well observed, that, the more barbarous the age and the music, the more powerful its effects;

> "For still the less they understand
> The more they admire the slight of hand."

In China the music is still barbarous enough, whatever the people may be who can admire it. It has neither science nor system; but, from a strange confused account given by Pere Amiot, of the generation and true dimensions of the tones (not one word

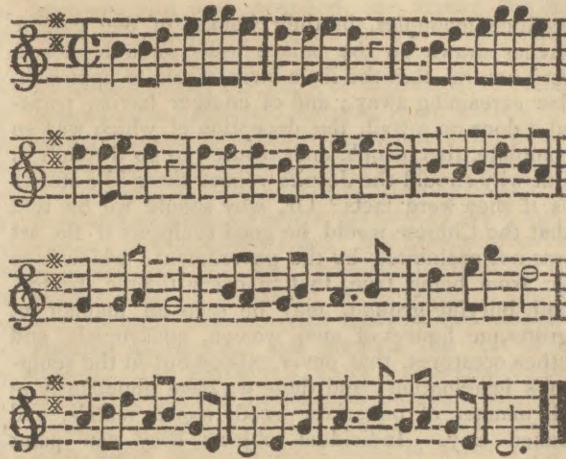
of which, as he afterwards acknowledges, he could understand), the Abbé Roussier concludes, that, like the music of the Greeks, it appears to be the remaining fragments of a complete system, belonging to a people more ancient than either of them. It will, perhaps, be safer to follow Dr Burney's conclusion, "that, from all the specimens he had seen of Chinese music (and he quotes Dr Lind, who resided some time in China, in support of his opinion), all the melodies of this nation have a very strong analogy to the old Scottish tunes;" that "the Chinese scale is very Scottish;" that "both resemble in their melodies the songs of ancient Greece;" and that, "the music of all three ought to be considered as *natural* music."

The Chinese airs are almost invariably sung in slow movements, generally plaintive, and mostly of a querulous or complaining cast; and they are always accompanied by some stringed instrument in the shape of a guitar. They make use, in singing, of so many shakes, their airs abound with so many half and quarter tones, that they are dull, drawling, and drowsy.

Their gamut consists of five natural notes, which they distinguish by five characters of the language, and two semitones; but they use neither lines nor spaces to note down their music. They, however, write down in succession the characters or notes in a column, as they are played, though it does not appear that they pay any attention in marking the time, the key, the mode of expression, &c. but acquire their airs by dint of labour and imitation. Their gamut for instrumental music is so imperfect, and the keys so inconsistent, wandering from flats to sharps, and the contrary, that they are under the necessity of being steadied and directed by a bell or cymbal. They always play, or endeavour to play, in unison, having no idea of counterpoint and parts in music. The band of Lord Macartney, on this account, afforded them no pleasure, except when it played some simple air, such as "Malbrook," or the national song of "God save the king." Some of their instruments, however, do occasionally rise to the octave in the accompaniment.

The instruments in general use are enumerated in the *Encyclopædia;* but there are many others of a similar kind, differing only in their form and the materials of which they are constructed. The wind instruments are, in general, shrill, harsh, and discordant; the drums, bells, cymbals, and other pulsatory instruments, loud and jarring; and the stringed instruments meagre and jingling. The sweetest instrument is a small organ, made of unequal reeds stuck into the upper surface of a hollow cup of wood, of which there are numbers in this country, but for which Dr Burney tried in vain to adapt a scale. This we believe to be the same *tibia* which that literary coxcomb Isaac Vossius maintained to be superior to all the instruments of modern Europe.

As a favourable specimen of Chinese music, the following national song of *Moo-lee-wha* is here inserted:



This air was played by Lord Amherst's band, and delighted the Chinese more than any other.

It may be added, that the affected gravity of Chinese manners, and their unsocial mode of life, are unfavourable to the cultivation of music, which cannot be expected to arrive even at a state of mediocrity, among a people who rarely assemble together, who take no enjoyment in the amusement of dancing, and whom the loves and the graces have not as yet condescended to visit.

Painting.

In a country where every kind of luxury is discouraged, and some of them constitutes a crime; where property is so precarious as rarely to descend to three generations; and where the useful only is affected to be considered as valuable, no great progress can be looked for in the fine arts. For the same reason that their poetry is deficient in invention, imagination, and dignity of sentiment, and their music of harmony, the sister art of painting is wanting in all the requisites that are considered to be necessary to form a good picture. Indeed, it could not well be otherwise; as, independent of their contracted ideas, they offend against every principle of perspective which, with the effects produced by a proper disposition of light and shade, they affect to consider unnatural. That it is not from want of talent that their drawings and paintings are so extravagantly outré, is sufficiently proved by the facility and accuracy with which the painters of Canton copy any picture put into their hands, whether on paper, glass, or canvas; and, so far from the Abbé Grozier's Parisian idea being true, that their best works are executed in Pekin, the very reverse is the case: all the arts, manufactures, even down to common printing, being worse executed in the capital than in any other city of the empire; and the reason is obvious enough; for the moment that a man acquires a superior reputation, he is summoned to the palace, where, within its spacious precincts, his talents must be exercised for the emperor alone. Here their arts and manufactures remain stationary, while the artists of Canton, being in the habit of copying from better models, are superior to any that the imperial palace can boast. It is all very well for a Chinese to pretend, that the ancients greatly excelled the moderns in the art of painting, and to

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produce examples, in their books, of one painter having drawn on the palace walls some hawks so very natural, that the little birds, afraid to approach, flew screaming away; and of another having painted a door on a wall, the deception of which was so complete, that people endeavoured to go through it. But why should the Jesuits repeat these idle stories as if they were facts? Or, why should we be told that the Chinese would be good sculptors if the art was not prohibited by the government? which is so far from being true, that in every temple, bridge, and burying-ground, may be seen all manner of grotesque figures of men, women, quadrupeds, and other creatures, that never existed but in the sculptor's imagination; and these we have abundantly in all manner of materials, wood, stone, metals, and baked clay. Individual objects they can paint with great accuracy; and in a composition each individual object is represented as close to the eye. Thus, the leaves of trees, however distant, are distinctly represented; and objects in the background are painted of the same size with those of the same kind in the foreground, which they absurdly contend to be proper, because they are so in nature. It may be doubted, whether the most skilful European artist can excel a Chinese in painting a bird or a reptile, an insect, a fish, or a flower,—so correct is he to nature, that not one plumula of a feather, nor a single scale of a fish, escapes him, and every shade and tint of colour is minutely imitated. It is strange, that a man of Pauw's sagacity should suffer his judgment to be so warped as to assign the "singular disposition of their optical organs" as the cause which prevented the Chinese from becoming good painters. As little truth is there in his assertion, that they are unable to copy from good models, without falling into their own style, and converting European eyes, ears, and noses, into those of a Chinese; they are the most servile imitators on earth. A Chinese will imitate the likeness of any object in shape, colour, and proportion. Though, when left to himself, he has no mind to convey the idea of distance, solidity, expression, and magnitude of objects, by fore-shortening, perspective, and a due distribution of light and shade, yet he will copy them all in a picture with scrupulous accuracy.

Sculpture.

Sculpture has been thought by some to date its improvements, if not its origin, from monumental edifices. No country can boast a greater number or variety of objects of this nature than China, but, like the rest of its edifices, they are totally destitute of the character of solidity and duration. A few monsters, or distorted forms of men and domestic animals, generally moulded in clay, are sometimes placed among the tombs, but they are wholly undeserving of notice. In cutting wood, in forming the root of a plant into the shape of human beings, quadrupeds, or monsters, they succeed better; and communicate to the features or to the action a high degree of expression; the same things occur in metal and in porcelain; but the human figure is always clothed, and a naked statue never seen. Some of the gigantic clay figures in the temples are by no means void of character and expression, and the images cut in stone, which sometimes adorn the avenues to the palaces, the gates of cities, and the parapets of bridges, monstrous as they generally are, show that, by proper encouragement and instruction, they are capable of producing something better; but they seem to be deficient in taste and feeling, and to possess no general ideas of the beauties of nature. Content with the representation of individuality, the imagination is never called into play; they servilely imitate what appears before them, with all its beauties and all its blemishes. They are neither deficient in ingenuity or dexterity. They engrave with a tool on copper, on silver, or on wood, as well, generally speaking, as the same kind of work can be executed in any part of Europe; and they are expert enough as lapidaries, in cutting all sorts of precious stones. They use spectacles made of crystal.

Architecture.

It is somewhat remarkable, that a government so long and so firmly established, and a population so numerous and civilized, should, at no period of its history, have constructed a building, public or private, that could deserve the least attention or admiration for its form, solidity, or magnitude, or that could possibly resist the action of two or three centuries; such is the obstinate and inveterate adherence of this people to ancient usage, which has narrowed and confined their ideas in the construction of their dwellings to the primitive tent. Perhaps, however, the want of permanent security to private property may have operated against the construction of solid and expensive edifices, and confined them to the less durable materials of half-burnt bricks, mud, clay, and wood. This is more likely to be the case than the absurd and ridiculous reason assigned by Grozier, that the heat and moisture of the southern provinces, and the rigorous cold of the northern ones, would render buildings of marble and other stone unhealthy and scarcely habitable, and that the same reasons equally operate against a number of stories, as the second and third would not be habitable. If the Abbe Grozier had passed but a single summer's day under the roof of one of the magnificent stone buildings of Calcutta, and another under a Chinese tent, he would not have committed such nonsense to paper. From the want of windows in their houses to the street, and from the small courts behind being barricadoed by high walls, which overtop the roofs, and conceal the dwellings from adjoining courts, it may perhaps be concluded that privacy and jealousy of their women, have been the causes that prevent the Chinese from building second and third stories to their dwelling-houses. The Missionaries, however, have assigned the frequent earthquakes in the northern provinces, as the cause of the lowness of the houses and slightness of the materials; as if men would speculate, over a whole empire of unparalleled extent, on a contingency which might never happen, and which, when it had happened, was confined to certain limits. The eruptions of Vesuvius have not prevented the inhabitants of Naples from building palaces, much less the Russians from rebuilding Moscow,—though the distance between these two

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cities is not greater than that of Pekin, where earthquakes are frequent, to that of Canton, where they never happen.

One can scarcely give credit to the disastrous effects produced by these earthquakes. The lives that have been lost are reckoned in Chinese history by hundreds of thousands, especially under the Mongoos dynasty. This might lead to a suspicion of exaggeration, as famines, earthquakes, and inundations, are considered by the Chinese as the scourges inflicted by heaven on the people, to show its dislike to a sovereign whom it disapproves, did not the accounts of more recent earthquakes given by the Missionaries, who were eye-witnesses of their tremendous effects, correspond with those recorded in Chinese history. It is stated by Pere Mailla, that, in 1679, in the reign of *Kaung-he*, more than 300,000 inhabitants of Pekin were buried under the ruins of the houses thrown down by an earthquake; that, at the same time, above 30,000 persons perished in the city of Tong-tchoo. The statements, however, of the Missionaries are vague and discordant. Pere Couplet says, *Sub decimam horam matutinam, regiam urbem et loca vicina tam horribilis terræ motus concussit, ut innumera palatia, deorum fana, turres et urbis mœnia corruerint; et sub ruinis sepulta quadraginta hominum millia.* Again, in 1730, in the reign of *Yong-tchin*, a violent earthquake shook the capital to its foundations, and 100,000 of its inhabitants were crushed to death. The earth opened in various places, black volumes of smoke issued forth, and left behind large pools of water. The city of Pekin is represented as affording a horrible spectacle; its walls, its palaces, the public buildings, two of the Jesuits' churches, and a multitude of dwelling-houses, were wholly, or in part, thrown down. The palace of the emperor, more solid than any other edifice, was greatly injured; that of *Yuen-min-yuen* was scarcely repairable. Of the 100,000 inhabitants contained in the adjoining village of *Hai-tien*, 20,000 are stated to have perished. The imperial family betook themselves to their barges in the canals, within the precincts of the palace. The emperor distributed many millions of money to the sufferers, and gave the Jesuits one thousand ounces of silver towards the expence of repairing their churches.

If earthquakes were to throw down the tall and ill-built brick pagodas of seven and nine stories in height, there would be nothing surprising; yet these appear to stand the shocks, and many of them are evidently among the oldest buildings in China. These, and the temples of Fo and Tao-tse, are among the most striking buildings of the country. The want of a national or state religion will best explain the want of those magnificent edifices in China that almost every other civilized nation has reared to the objects of divine worship. Some of their bridges are light, and sufficiently pretty in their appearance; but they are generally slight, and faulty in their construction. They consist of every possible variety of form. Their monuments to the memory of the dead are still more various than their bridges, but they are poor in design and bad in execution. Wooden pillars, forming a triple gate-way, roofed over, and painted, gilt, and varnished, are among the most striking objects that catch the eye of a stranger. They are monuments erected at the public expence, in streets, or by the sides of highways, to commemorate some celebrated warrior, some ancient mandarin, or some antiquated virgin, who had withstood temptation, and never swerved from the strict rules of decorum. To such a one will probably be inscribed in letters of gold, "Honour granted by the Emperor—to icy coldness, hard frost." But these *pei-loos* have little permanency. The mandarin to whom the Emperor's order is addressed for erecting it, employs a carpenter, contracts for building the edifice as cheaply as he can, and pockets the rest of the money. The Emperor's object is answered by publishing the edict in the National Gazette. It is handed down to posterity in the great history of the empire, whilst the monument itself in a few years is consumed by the dry rot, and is seen no more.

Superior as the temples and palaces of the Hindus and Mahometans in India and Persia, and indeed throughout Asia, are to those of the Chinese, the dwellings of the latter are infinitely more comfortable in every respect than those of the former. Their stoves for warming the apartments and for cooking, their beds and furniture, bespeak a degree of refinement and comfort unknown to other oriental nations; but the great characteristic difference is, that the Chinese sit on chairs, eat off tables, burn wax candles, and cover the whole body with clothing.

Naval Architecture.

Their naval architecture wears the stamp of great antiquity, and is exceedingly grotesque. They have, in fact, made little progress in maritime navigation, from the inveterate dislike of the government to all foreign intercourse, and to all innovation. The very same kind of vessels as those described by Marco Polo at the port nearest to Pekin, in the thirteenth century, were found without variation by Lord Macartney, five hundred years afterwards, and, accurate to the Italian's description, even to the number of compartments into which the hold of each vessel was divided. They had anchors of wood, and ropes and sails of bamboo. The boats and barges for internal commerce and communication are very varied, generally commodious, especially the passage-boats on the grand canal, and all of them suited to the depth and velocity of the stream, and the width of the locks and floodgates of the respective canals and rivers which they are intended to navigate. These vessels are so numerous as almost to supersede the necessity of land-carriage; and the most common and convenient mode of travelling in China is in barges, which are generally provided with cabins for sleeping, and a kitchen and utensils for cooking victuals. Their military navy is unworthy of the name. It consists of a flotilla, whose principal occupation is that of conveying soldiers where they may be wanted, and looking after pirates and smugglers. An English frigate would beat the whole naval force of China. (Grozier, Du Halde, Barrow, De Guignes, &c.)

Military Architecture.

The state of their military architecture and military science is equally rude and imperfect. There is nothing, in fact, from the celebrated wall on the

side of northern and western Tartary, to the mouth of the Bocca Tigris near Canton, that merits the name of a fortress. They are all of the same construction, being mounds of earth heaped into the shape of a wall, and cased on each side with bricks, and flanked with square towers at bow-shot distance; and with walls of this description all their cities are surrounded.

Military and Defences.

The best defences of China are its great distance from any civilized country; its rugged mountains and sandy deserts on one side, and a stormy sea, whose navigation is but little known, on the other. In its military strength it can place little or no confidence,—a fact which has frequently been proved by the successful incursions of the Tartars, who have twice since the Christian era conquered the whole country, and changed the ruling dynasty. There is little doubt, indeed, that a well appointed army, of 15,000 or 20,000 men, led by an experienced general, would easily make its way from Canton to Pekin. It has been supposed, from their skill in fire-works, and from the frequent mention of them in ancient books, that the deflagrating power of nitre, sulphur, and other ingredients, were well known to them; but it is pretty evident that they had but an imperfect if any knowledge of cannon or musquets, before the arrival of European missionaries in the capital. We may form some notion of the mode of fighting of the Tartars and the Chinese about the Christian era, from the memoir of a general officer, presented to the Sovereign, when about to make war on the Tartars.

"The manner (this general says) in which the Tartars carry on war is very different from ours. To mount up and descend the steepest mountains with astonishing rapidity; to swim deep and rapid rivers; to brave storms of wind and rain, hunger and thirst; to make forced marches, and overleap all impediments, training their horses to tread in the narrowest paths; expert in the use of the bow and arrow, they are always sure of their aim—such are the Tartars. They attack, retreat, rally, with a promptitude and facility peculiar to themselves. In the gorges of the mountains, and in the ravines and deep defiles, they will always have the advantage over us; but on the plains where our chariots can perform their evolutions, our cavalry will always beat theirs. Their bows have not the strength of ours; their spears are not so long; and their arms and arrows are inferior in quality to ours. To stand firm, to come to close quarters, to handle the pike, to present a front, to cut their way when surrounded, are the proper manœuvres of our troops, of which the Tartars are ignorant, and against which they can oppose no successful resistance. In such situations, with equal numbers, our forces are as five, when the Tartars are but as three." *(Hist. Gen. de la Chine.)*

The first mention of anything like fire-arms, and that is but an equivocal one, is in the year 1219, when Gengis-khan was penetrating the provinces of China. It is stated, that the Chinese, from the turrets of the walls of *Tsao-yong*, played their machines called *pao* (the present name of guns), by which they killed great numbers at every stroke. Again, when *Ogdai-khan* laid siege to *Lo-yang*, the Chinese commandant *Kiang-chin*, invented a kind of *pao*, which hurled large stones to the distance of one hundred paces, with such accuracy as to strike any point that might be desired. But another passage is more to the purpose. The Tartars are said to have breached an angle of the wall, by employing more than 100 machines, consisting of tubes, each made of thirteen laths of Bamboo; that the Chinese repaired these breaches with wood, straw mixed with horse dung, &c., which the Tartars set on fire with their *ho-pao* (fire-tubes), and immediately afterwards we find these *ho-pao* called *Tchen-tien-ley* (heaven-shaking thunder); and it is further stated, that a certain substance put into them, when set on fire, explodes like a thunder clap, loud enough to be heard at the distance of a hundred *lee* (30 miles). This description, and that of the effects produced, leave no doubt of these bamboo staves, hooped together, being the first attempt in China at the use of cannon, to which succeeded, probably, those of plates of malleable iron, also hooped together, several of which kind have been found in India, and also seen by Bell lying in heaps, within the walls of a city near the great wall.

In 1453, we find mention made of chariots of war, carrying cannon in their fronts; but, it is probable, they knew very little of the use of them; for when *Chin-tsing*, in 1608, made war upon the Tartars on the northern frontier, and was defeated, the Portuguese at Macao, availing themselves of the panic into which the Chinese were thrown, made an offer of assistance with a party of artillery. A Jesuit was dispatched from the capital to hasten the new auxiliaries. The party consisted of 200 Portuguese, and as many Chinese, trained and exercised in the European manner; and they were commanded by two Portuguese Captains, Pierre Cordier, and Antoine Rodriguez del Capo. They were feasted and treated with distinguished honours on their passage to the capital, where they were well received and generally admired, except in the cut of their jackets, which, according to Chinese notions, were too scanty to be elegant. Their admiration, however, soon ceased, and in a few days they were sent back to Macao. It is stated, however, by one of the missionaries, that this was owing to a Portuguese and four Chinese being killed in firing them. That the Jesuit Verbiest taught them how to cast cannon there can be no doubt, for the president of the tribunal of rites thanks the missionaries for this signal service; and the matchlocks now in use by the Chinese troops, are nothing more than the old Portuguese matchlock.

The Tartars are soldiers by profession, mostly cavalry, and their arms, the bow and a broad scimitar, which they wear on the left side, with the point forwards, and which they draw by carrying the right hand behind them, in order (they say) that their adversary may not cut the arm when in the act of drawing. They are arranged under eight banners, distinguished by different colours. The Chinese soldiers are for the most part a sort of militia, enrolled for the defence of the extended frontier, guards to the city gates, the military posts placed at certain distances along the roads, rivers, and canals. All expresses are forwarded from post to post by the soldiers. Vast multitudes are employed to assist the civil magistracy,

and act in the cities as police-officers. Their dress and appearance are most unmilitary, better suited for the stage than the field of battle,—their paper helmets, wadded gowns, quilted petticoats, and clumsy satin boots, are but ill adapted for the purpose of war. Indeed, unless it be to quell an insurrection, or to pursue bands of robbers, the Chinese military are rarely called away from their pacific employments. There was some anxiety, on the return of Lord Amherst through the country, that the military should put on an imposing appearance. "Through the whole route," says the Emperor, "take care that the soldiers have their armour fresh and shining, and their weapons disposed in a commanding style, and that an attitude be maintained at once formidable and dignified."

The people are all enrolled for service, when called upon, from a certain age. A father of a family, having a certain number of children, is exempt from service—an only son, and a son who supports his parents, are both exempt. Great distinctions are shown to those who fall in battle. The body of an officer is burnt, and his ashes, with his armour, and a suitable eulogium, sent to his friends; the bow and sabre of a common soldier slain in fight are sent to his family; rewards are distributed, and honourable mention made of the deceased in the Pekin Gazette.

Since the conquest of Western Tartary, completed by Kien-long, they are not likely to be engaged in any foreign wars. If the neighbouring states, which pay a nominal vassalage, contribute nothing to their wealth or strength, neither are they likely to give them trouble or uneasiness: they have nothing to apprehend on the side of Tartary but an irruption of the Russians, an event which has been supposed not altogether foreign to the plans of the present autocrat of that overgrown empire. (*Hist. Gen. de la Chine concernant les Chinois.*)

Sciences.

Nothing has yet appeared in Europe from an authentic source, to warrant any other conclusion than that of the utter ignorance of the Chinese in the pure, speculative, and abstract science of mathematics. Their knowledge of arithmetic and geometry is bounded by mere practical rules. Their numerical notation is marked down by symbols of the language, as that of the Greeks and the Romans was by letters of the alphabet; and, like them, the Chinese symbols want that power of position which the Arabic numbers possess. The common operations of arithmetic are generally performed by a few balls strung on wires, somewhat resembling the Roman abacus, and sometimes by the joints of the fingers. (See Arithmetic in this *Supplement.*) The measure of quantity is usually determined by reducing all surfaces and sides to the dimensions of squares or cubes; and with those few practical operations, they contrive to manage all the common purposes of life.

Yet the Chinese have been represented by some of the French missionaries as profound astronomers, at a time when all Europe was in a state of barbarism; as being able to calculate the recurrence of eclipses; to adjust the irregular motions of the sun and moon; to measure the distances of the planets, &c. The ridiculous ceremonies observed by the great officers of state when eclipses happen, furnish, it is true, no proof against the knowledge of their causes. A government established on ancient customs cannot afford to lop off any of its props; and the foretelling of eclipses, the frightening away the dragon that would devour the sun or moon, the favourable or unfavourable omens of the heavenly appearances, are so many engines for keeping the ignorant in awe. The Imperial Calendar is an admirable coadjutor with the Imperial Gazette. But when we find, from their own annals, and from the report of the earliest travellers, that foreigners have had the superintendence of the astronomical part of this almanac, and that, from the defective knowledge of these foreign astronomers, and the occasional want of them altogether, the national calendar, as declared by one of their emperors, had undergone no less than seventy-two revisions, it may safely be concluded that the Chinese know very little of the matter. M. Freret says he had in his possession the copy of a celestial chart, constructed in China about the sixth century of the Christian era, on which were inserted 1460 stars in their proper positions, at least sufficiently near to be recognised, but this may have been made mechanically, and perhaps by a foreigner. It is recorded in their annals, that in 718 of the Christian era, an Indian astronomer of the name of *Koo-tan* having brought from the west a treatise on astronomy, was employed at court to translate it into the Chinese language; and they also mention that Kub-lai-Khan encouraged learned men to remain in China; and that under his reign an Arab astronomer was employed in rectifying the calendar, and constructing astronomical instruments. Since that time Armenians, Bucharians, Hindoos, Arabs, and Christians, have presided over the Board charged with the construction of the National Almanac, in which the native Chinese took no other part than that of assigning the lucky and unlucky days, what was to be done and what abstained from on those days, &c. When Lord Macartney was in Pekin, a Portuguese, who called himself Bishop of Pekin, a person of no great skill in mathematical knowledge, presided over this Board. Indeed the state in which their calendar was found when Adam Schaal, one of the earliest Jesuits, made his way to Pekin, sufficiently proves their ignorance of astronomical calculations, an intercalary month having been introduced into the wrong year. On making them acquainted with this blunder, all the departments of the state, ordinary and extraordinary, were summoned to sit in judgment on the good father's report, which they voted to be erroneous, and that the ancient system should be continued. They kept, however, the learned Jesuit at Court, and quietly allowed him to set them right. The Emperor *Kaung-hee*, who seems to have entertained no high opinion of his Chinese subjects, brought the Chinese President of the Board of Astronomy to trial, because he could not calculate the length of shadow which a gnomon would throw, but which was immediately done by Father Verbiest. This intelligent Tartar put himself under the tuition of the Jesuits, who made for him a quadrant, translated into the Chinese language a set of logarithm tables,

which were printed, and a copy of which is now in the library of the Royal Society of London,—a very beautiful specimen of Chinese typography. Kaung-hee carried these tables and his quadrant suspended from his girdle, and when in Tartary is said to have constantly amused himself in taking angles, and measuring the height of mountains.

The Chinese system, if system it can be called, of astronomy, resembles so closely that which remains of the Hindoos, that both must have been derived from the same source. The period or cycle of 60 years, by which their chronology is regulated, the period of 10,800 years, observed by the *Tao-tse*, which is the sum of the first three Hindoo ages, with their intermediate periods, the division of the Zodiac into 12 signs, and also into 28 constellations or habitations of the moon, corresponding with the 28 Hindoo nacshatras, are so many proofs of a common origin; and both may perhaps have derived the remains of this science from some third nation, more ancient than either; as the little which both nations do possess, appears to be the remains rather than the elements of the science.

The system of policy which discouraged all intercourse with strangers,—which set no value on foreign commerce and navigation,—which cultivated no language but that of the country, which was unintelligible to other nations, must necessarily have kept the people of China in ignorance of all the rest of the world. China was to them, in fact, the whole world. It appears, however, that, at a very remote period, they had intercourse with Pegu, Siam, Malacca, Hindostan, and several of the Asiatic islands. Two centuries before the Christian era, they had a knowledge of the upper regions of Tartary, and one of their travellers gives an account of an inland sea, into which the rivers running to the westward were received, which could be no other than the Caspian. The great islands of Borneo, Java, Sumatra, and Ceylon, are names easily recognised in their annals, on which great numbers of Chinese are still found, retaining their original language, manners, and government. Captain Sayer, of his Majesty's ship Leda, on ascending a river of the western coast of Borneo, came unexpectedly on a colony of Chinese in the interior, consisting of not less than 200,000 or 300,000 persons, all united under one chief or captain; and Mr Raffles says, that, near the same place, it has been calculated that the number of Chinese employed in the gold mines alone, amounts to 32,000 working men.

Their knowledge, however, of their immediate neighbours was very limited and imperfect. By the aid of practical geometry, they had a tolerable notion of their own country. Pere Mailla asserts, that, on comparing the ancient chart of China, said to be copied out of the *Shoo-king*, with the actual survey made by his brother Jesuits and himself, and which took them ten years to complete, they found the limits and the positions of the provinces, the courses of the rivers, and the direction of the mountains, pretty nearly to accord, but the proportions of the objects to each other, and to the whole, were not in the least observed. He further observes, that they saw and gazed with astonishment and admiration at the chasms which the Emperor *Yu* caused to be cut through solid mountains, to open new channels for the waters of the Yellow River. Some, however, will be apt to conclude that it was the water itself, and not the Emperor *Yu*, which opened these channels.

Of natural and experimental philosophy, they know only what the Jesuits taught them, and that appears not to be much. Of clock-making, dialling, optics, and electricity, they know nothing; of hydrostatics and hydraulics, very little; they raised water by a machine resembling the Persian wheel, and by a large wheel, with bamboo tubes fixed obliquely on its rim; but they were ignorant even of the principle of the common pump. The use of most of the mechanical powers is known to savages, but the most commodious and effective application of them was not known to the Chinese; in most cases, manual strength supplied the place of mechanical power. When Mr Barrow, in delivering the presents to the Emperor Kien-long, failed in making him comprehend the use of the mechanical powers from a complete set of models, the old man observed, that they might serve as play-things for his grandchildren.

State of the Liberal Professions.

The nature of their own language, their universal ignorance of any other, and their pertinacious resistance to all intercourse with foreigners, may explain the low ebb of the sciences and liberal professions in China. The maxims of the sovereigns and sages of antiquity,—the rites and ceremonies and duties required by the civil and religious institutions of the empire,—the laws and customs,—are the points of knowledge which lead to wealth, power, and distinction in the state. As there is no established religion, so none are paid or preferred by the government for instructing the people; as there is no pleading in criminal or civil suits, so there are none who act as attornies or advocates; and the practice of physic is attended with too little either of honour or emolument to excite emulation in men of rank and ability in the pursuit of it, and is generally in the hands of the sectarian priests of Fo and Tao-tsé, or of low vulgar quacks. Without the least knowledge of anatomy or surgery, they can know little of the animal economy. The seat of the disease they pretend to discover by the quackery of the pulse, by the eye, the nose, the tongue, the ears, and the voice. When this is ascertained, they prescribe their vomits, purges, febrifuges, &c. extracted from the three kingdoms of nature, of which mercury, antimony, rhubarb, and gin-seng, constitute no inconsiderable part; of gin-seng alone, they profess to have no less than seventy-seven preparations. Their surgery consists chiefly in acupunctuation and shampooing, and is practised chiefly by the barbers. There are certain persons whose occupation is to discover whether those who may be found dead, have died a natural death or by violence, whether by their own means or that of others, and the verdict of the criminal court is often grounded on the decision of these quacks.

The Emperor *Kaung-hee* soon convinced himself that several of the Jesuits were better skilled in medicine than his own physician. At first, however,

he had some scruples, upon being attacked by a fever, of following their advice. Three of the first physicians to the court, dissuaded him from taking a medicine, of whose qualities they professed themselves ignorant, and advised him to let the disease go on, that they might discover its true character. The emperor, however, at last took the Peruvian bark which the Jesuits had prescribed, and soon recovered; but it is said in the *General History*, that several officers, who had similar fevers, were first ordered to take the bark, and finding it at least harmless, he then ventured upon it himself. As ignorance is a crime in the eyes of the ignorant, it is more especially so at the court of China, and made capital in those to whom the life of the sovereign is entrusted. The three physicians were therefore delivered over to the criminal court, who condemned them to death; but Kaung-hee mitigated the punishment to that of exile, and rewarded the Jesuits with a house in Pekin, and contributed largely towards the building of a church.

Kaung-hee was a man of great humour, and used frequently to joke with the Missionaries respecting their religion and the customs of their country. One day he asked Mezzabarba, the pope's legate, if it was the custom in Europe to condemn a man to death without sufficient proof of his guilt? and being answered in the negative,—" One cannot," says the emperor, " attach too great a value to the life of man;" and turning to his body physician, and ordering him to approach, " Here," continues he, " is a much more formidable person than myself; I can only put a man to death on legal proof of guilt, but this fellow can dispatch whomsoever he pleases without the form of trial."

Whoever may be curious to see the quackery of the pulse detailed, without a complete knowledge of which a physician would gain no réputation in China, may find a translation of the doctrine in the collection of Du Halde.

The Chinese are subject to a species of contagious leprosy, which their physicians cannot cure, and which the law ordains to be a legitimate cause of divorce, as the only means to stop its progress. The itch is most prevalent, and cutaneous disorders of various kinds very common; but they have escaped the plague, more, as Pauw thinks, by constant ventilation,—by burning sandal-wood dust, and other odoriferous woods,—by the abundant use of musk and various strong scented drugs, than by any attention to cleanliness; perhaps, also, the universal smoking of tobacco may have contributed to save them from the horrors of the plague. (*Hist. Gen. de la Chine* par Du Halde.)

Mechanic Arts.

Though little progress has been made in any of the liberal arts, or abstract sciences, or little as they are likely to advance under a system of government which interdicts all intercourse with foreign nations, the arts which necessity demands,—which add to the conveniences, and increase the comforts, of a civilized state of society, seem to have flourished at a very early period of their history; and many of them have been brought to a degree of perfection which is still unequalled by the most polished nations of Europe. Whatever depends on mere imitation and manual dexterity, can be executed as well, and as neatly, by a Chinese, as by the most skilful artists of the western world; and some of them in a style of very superior excellence. No people, for example, have carried the art of dyeing, or of extracting dyeing materials from so great a variety of animal, mineral, and vegetable substances, as the Chinese have done; and this merely from a practical knowledge of chemical affinities, without troubling themselves with theories derived from scientific principles. In like manner, practice has taught them how to detect the exact proportion of alloy that may be mixed with gold and silver, and how to separate it. We import from China their native cinnabar, but our vermillion, extracted from it, is not to be compared with theirs for brilliancy and deepness of colour, which is supposed to be given to it by long and patient trituration under water. Again, their beautiful blues on their porcelain are more transparent, deep, and vivid, than the same blues applied to our pottery ware; yet we supply the Chinese with the same cobalt frits from which our own colours are extracted. It has been supposed, that the greater or less brilliancy of the colours used for painting porcelain, depends more on the nature of the glaze on which they are laid, than on their own intrinsic merits. Here, then, we have something still to learn from the Chinese. The biscuit of their porcelain, too, is much superior in whiteness, hardness, and transparency to any which has been made in Europe. The Swansea porcelain comes the nearest to it in these respects, supposed to be owing, in some degree, to a proportion of magnesian earth being mixed with the aluminous and silicious ingredients. In form and decoration, which depend on a taste and feeling which the Chinese are strangers to, we far surpass them.

In the cutting of ivory into fans, baskets, pagodas, nests of nine or more hollow moveable balls, one within the other, beautifully carved, the artists of Europe cannot pretend to vie with the Chinese; yet it does not appear that they practise any other means than that of working in water with small saws. As little can Europeans pretend to rival their large horn lanterns, of several feet in diameter, perfectly transparent in every part, without a flaw or opaque spot, and without a seam; yet a small portable stove or furnace,—an iron boiler, and a pair of common pincers, are all the tools that are required for the manufacture of those extraordinary machines. In silver fillagree they are, at least, equal to the Hindoos, and their lacquered cabinets, and other articles, are excelled only in Japan. They are not less expert in cutting tortoise-shell and mother of pearl, and all kinds of gems and stones. They have a method of ornamenting their cabinet wares, tea-chests, &c. with spangles laid on with the black varnish in the shape of plants, birds, insects, &c. exhibiting varied iridescent colours, appearing like metallic scales that have undergone the process of heat; but they are nothing more than the thin lamina of a particular species of shell (*Helix*) which they have a method of separating by boiling, as they pretend, for the space of half a moon. In all the metals they work with neatness; and if they make not a lock or a hinge

China.

that an English artist would look at, it is only because a Chinese would not pay the price of a good one. Their white copper is a metal, or a mixture of metals, unknown in Europe; and though we think that we have ascertained the component parts of the famous gong to be copper, tin, and bismuth, we are yet unable to make a Chinese gong. In works of the loom, and especially in the manufacture of silk and satin cloths, we cannot pretend to cope with them; and their silken twisted cords, tassels, and all kinds of embroidery, in general the labour of females, are extremely beautiful. In the variety of gums, spices, perfumes, they excel the rest of the world. Our artists can attest the excellence of their ink, and their paper and printing may challenge those of Europe. Many other branches of the mechanical arts might be enumerated, in which the Chinese may consider themselves as second to none, but those already mentioned are sufficient to exemplify their skill in this respect. There are no manufactories carried on by machinery, or on a great scale. Generally speaking, each individual in the country spins, weaves, and dyes his own web. It would appear, however, from some regulations laid down in the *Leu-lee*, that of porcelain, silks, satins, and certain other articles, government is its own manufacturer. The manufactories of porcelain and the coarser kinds of pottery, for the sake of the coal, are mostly in Kiang-see, and the village of Kin-techin, it is said, contains nearly a million of people, all of them engaged in the potteries.

Population.

There is no subject on which the accounts of the missionaries are so vague and contradictory as that of the population; yet they all affect to refer to official documents. They agree, however, in stating it to be something immense, though the highest number is not equal to two-thirds of the enormous mass of 333,000,000, which the Mandarins attendant on Lord Macartney's embassy gave to that nobleman as the amount of the population. The inaccuracy, however, not to say impossibility of that account, is obvious from mere inspection. The numbers in each province are given in round millions, and in two provinces the number of millions is precisely the same. In the *General History of China*, the population is frequently stated at different periods, but in a way so loose and vague as to deserve little attention. There can be no doubt, however, that, from time to time, a census is *ordered* to be taken, and the result of it is made public; that the number of *mouths* is always included; but that a separate list of the taxable inhabitants only is taken at the same time, and is all perhaps that the government cares about. Thus it is stated, that, under *Yang-tee*, in the 609th year of the Christian era, the empire contained 8,900,000 families, which, at six to each family, would give a population of 53,400,000; but, to show how very little numbers are to be depended on, it is also stated that China, at that time, was from north to south 14,815 *lee*, and from east to west 9300 *lee*, or 4444 miles by 2790, which is about three times its actual dimensions, or nine times its magnitude.

Again, it is stated that, in the year 1222, under the reign of *Hoei-tsong*, before the Tartar conquest, the Board of taxes ordered a census to be taken which amounted to 20,882,358 families, and 46,734,784 persons, or about $2\frac{3}{10}$ to each family, which is absurd. In 1290, after the Tartar conquest, Kublai-Khan directed a census to be taken of the taxables. It amounted to 13,196,206 families, comprehending 58,834,711 persons; but it is admitted that the state of the country prevented the whole being taken. In 1502, *Shiao-tsong* caused a census to be taken, the result of which is stated to have been 53,280,000 mouths. There is a strange difference between these numbers, and those which are published by Grozier, purporting to be a census of all the people in China, taken in the years 1760 and 1761, in the former of which, the list amounts to 196,837,977 *mouths*; in the latter to 198,214,553, making an increase in one year of 1,376,576 *mouths*.

If we are to give credit to these accounts, we must suppose that the population of China must have attained its prodigious magnitude within the last two or three centuries, and that it must be greatly on the increase; but we are immediately stopped short from drawing this conclusion, by the translation of some statistical accounts of China by Mr Morrison, taken by order of the present emperor *Kia-king*, to compare with a similar statement made at the commencement of the reigning dynasty. According to this census, the total population, including the twelve Tartar banners, and all ranks and conditions, great and small, amounts to between 145,000,000 and 146,000,000 of mouths; and this account agrees very exactly with that census taken by Kien-lung in the year 1743, and contained in the *Ye-tung-tché*, or *All matters concerning China*, a curious work we have before mentioned. By this census, the number of heads of families paying taxes is stated at 28,514,488; which, by reckoning five persons to each family, would give 142,582,440. The number of the literati, the military, and others exempt from taxation, will amply make up the deficiency. Grozier, indeed, by the omissions of P. Amiot, and the exempts as above mentioned, swells the total to 157,301,755.

Resources.

This enormous population is fed and subsisted, and all its wants entirely supplied, from China alone. Except a few English broad cloths and metals, a few furs from Russia, and a little cotton from Bombay, it receives but little external supplies. The extent and fertility of the soil are amply sufficient for its demands. China consists, at least, of one million and a half of square miles, and has about 97 persons to a square mile. Deduct a third for waste lands, lakes, and mountains, and 640,000,000 acres still remain, which give near $4\frac{1}{2}$ acres of land to each individual. The land is subject to an arbitrary tax, generally about one-tenth; and, in order to ascertain the revenue, a report was made to Kien-lung in the year 1745, of the amount of land under cultivation. It was as follows:

	King.
Land in the possession of individuals,	7,081,142
Belonging to the Tartar standards,	13,838
To the military, - - -	259,418
To the sectarian priests, -	3,620
To the literary, - -	1,429
	7,359,447

China.

Each *king* being 100 *moo*, and a *moo* equal to a superficies whose length is 2400 *tchee* and breadth 10 *tchee*. The *tchee* is about 14.55 English inches; so that the Chinese *moo* is to the English acre as 10,890 to 8821, by which it will be found, that, agreeably with the above statement, the land under cultivation was about 600 millions of acres.

Classes of Society.

The constituent parts of the population of China were anciently considered to consist of four classes; the *tsé*, or learned, who governed and instructed the rest; the *nung*, or agriculturists, who provided food and materials for clothing the rest; the *kung*, or artisan or manufacturer, who clothed, and built, and furnished houses for the rest; and the *shang*, who distributed and exchanged the productions of the other two among all the classes of society; but nothing like a division into *castes* ever appeared in China. On the contrary, every encouragement is held out for the children of the three inferior classes to aspire to the first.

The numbers of the *tsé*, or officers and literary men, consisting of the members of the several Boards, Governors of provinces and cities, Judges, Treasurers, Collectors, Commissaries, Inspectors, &c. with an enormous list of subaltern officers, according to Grozier, amount to 98,615, and of the literati, who every year take their degrees, and qualify for office, 24,701, the whole of whom living at any one time, cannot, he says, be estimated at less than 494,000. The military officers are also reckoned among the learned, and the number of those who have actual commands amount to 7411, each of whom, on an average, employs nine subaltern officers under him: the whole, therefore, of these would amount to 74,110, and the total of the military or militia is estimated at 822,621; but one of the officers of government told P. Amiot that the military exceeded two millions; and this agrees pretty nearly with the information given to Lord Macartney.

A court kalendar and an army list are published in Pekin four times a year, each consisting of several volumes; a tolerable proof of the frequent changes that take place in the subordinate movements of this vast machine.

The great mass of the people, however, are employed in productive labour; perhaps, on a rough estimate, full two-thirds in agriculture and the fisheries; the remaining third, after deducting the military, the civil officers, the students, and candidates for office, amounting, perhaps, on a rough guess, to about ten millions, are manufacturers, tradesmen, shopkeepers, and the multitudes that are employed in the numerous vessels and barges on the rivers and canals to carry on the internal commerce of the kingdom. Agriculture is the productive labour that has always received the highest encouragement from the government, and occasionally the Emperor himself has turned out into the field, with great pomp and solemnity, to hold the plough as an example to the peasantry; perhaps, however, as Pauw observes, if they would remove all the trammels from agriculture, it would have a better effect than the continuance of this ancient ceremony. These trammels are, however, fewer and lighter than in most countries. One-tenth of the estimated produce is all that is required for the state; and they have neither priesthood nor poor to maintain, each family being compelled by law and custom to take care of its poor relations, and the sovereign taking care of the spiritual concerns of his subjects. The monarch may be considered as the universal and exclusive proprietor of the soil; there is no such thing as freeholds; but undisturbed possession is kept so long as the holder complies with the conditions on which the land was granted. As there are no public funds, and capital vested in trade is not very secure, nor the profession highly esteemed, the purchase of land is the most eligible mode of rendering capital productive. Still there are very few great landed proprietors. Two reasons may be assigned for this: first, the rate of legal interest being as high as 3 *per cent.* for a month, it would be ruinous to borrow money on mortgage; and, secondly, it appears, by the penal code, that the proprietorship of the landholder is of a very qualified nature, and subject to a degree of interference and control, on the part of government, not known under any of the European governments. It can only be disposed of by will under certain restrictions; the inheritors must share it under certain proportions. If a proprietor should neglect to register his land in the public records, and acknowledge himself responsible for the payment of the taxes, such land becomes forfeited. If land, capable of cultivation, be suffered to lie waste through the inability of the proprietor to till it, another may obtain permission to cultivate it; the mortgagee becomes responsible for the payment of the taxes until the land be redeemed by the proprietor. All these restrictions operate against large landed proprietorships.

Agriculture.

Much has been said in praise of Chinese agriculture—much more, in fact, than it deserves; in Europe it would be despised. There are no great farms in China; few families cultivate more than is necessary for their own use, and for payment of the imperial taxes; and without teams of any kind; without any knowledge or practice of a succession of crops; without any grazing farms, for feeding cattle, or for the dairy, of which they are totally ignorant, making no use of either milk, butter, or cheese, they can have little manure, nor can the land be kept in good condition. In fact, the old fallowing system is followed, and, in many parts, the spade and the hoe are the great implements of cultivation, their miserable plough scarcely deserving the name. The command of water is the principal substitute for manure. Every substance, however, that can be converted into manure is most carefully collected; and numbers of old people and children of both sexes find employment in scraping together, with wooden rakes, into their little baskets, whatever may have fallen in the streets or roads, where these

> "Lean pensioners upon the traveller's tract
> Pick up their nauseous dole."—

Leaves, roots, or stems of plants, mud from the sides of canals, and every sort of offal that presents itself, of which human hair, shaven from the scalps of a hundred millions weekly, forms no inconsiderable ingredient, are carefully scraped together. Large earthen vessels are sunk in the ground, to

which, it is said, their cattle are taught to retire; and on the outskirts of many towns and villages are small buildings, invitingly placed for the accommodation of passengers who may have occasion to use them. All these resources, however, are very limited, and the utmost supply thus afforded can only serve for horticultural purposes.

The whole of the land in China, under cultivation, may be said to be employed exclusively for the subsistence and clothing of man. The staff of life is rice; and it is the chief article of produce in the middle and southern provinces. This grain requires little or no manure; age after age the same piece of ground yields its annual crop, and some of them two crops a year. In the culture of rice water answers every purpose; and nature has supplied this extensive country most abundantly with that valuable element. It is here that Chinese agricultural skill is most displayed; the contrivances for raising it out of rivers where the banks are high, by means of wheels, long levers, swinging buckets, &c.; or of leading it down from mountain springs, and along terraces levelled on the sides of hills, or in little channels across the plains, are all admirable; but when, from long drought, the rivers run low in their channels, and the springs fail, a scarcity of the crop is the inevitable consequence, and the effects of famine are most dreadful; for though the government has not been wanting in storing up a year's supply of grain in the public magazines (the produce of the taxes paid mostly in kind), yet, before the beneficent intentions of the sovereign can be carried into effect, there are so many previous memorials and references necessary, and so many forms of office to pass through, that the mischief has worked its effects before the remedy is applied; and, though in this vast empire the scarcity of grain may be local and partial, they have no relief to look to from without, and the system of external commerce is too slow in its operations to throw in a timely supply where it may be most wanted. In the northern provinces, where water is less abundant and less depended on, wheat, barley, buck-wheat, and a great variety of millets, supply the place of rice. Every where are met with leguminous plants of different kinds, pumpkins, melons, sweet potatoes, and whole fields of a luxuriant vegetable called *pei-tsai*, the white herb, apparently a species of brassica, which is salted for winter consumption. In Kiang-nan and Tche-kiang vast tracts of land are planted with the white mulberry tree as food for the silk-worms. They appear like a young orchard of cherry trees, being kept low by constant pruning, to make them throw out young shoots and fresh supplies of leaves. In all the middle provinces are large fields of cotton, which supplies the usual clothing of the great mass of the population, in addition to which, immense quantities are imported annually from Bombay. That peculiar species of a yellowish tinge, which we call Nankin, is not worn by the Chinese, at least in its natural colour; blue, brown, and black, are the prevailing colours. Patches of indigo are generally found in the vicinity of the cotton plantations.

The tea-plant, which forms so important an article for the common beverage of the country, and also for exportation, is cultivated only in particular provinces, and in certain situations; but it is found in gardens and small enclosures in every part of the empire, being very much of the habit and appearance of the broad-leafed myrtle. We scarcely yet know whether the different kinds of tea are from the same plant, or different species of the same genus. The leaf of the sou-chong is broader than that of the hyson, but this seems to constitute the only difference. Both sorts undergo the process of *roasting* in their iron pans; the black in a higher degree of heat than the green, which is sufficient to give a different character to the extractive matter from the two sorts; and the nervous quality usually ascribed to green tea, may be owing to the little alteration which the juices of the leaf undergo, from the small degree of heat that is used in the process. To procure the fine flavour, the Chinese usually press the green teas into the chests and cannisters while hot. They have a practice also of giving a finer bloom to dull green teas, by sprinkling a little indigo, mixed with powder of gypsum, while stirring the leaf about in the pan. The different sorts of black and green are not merely from soil, situation, and age of the leaf; but after winnowing the tea, they are taken up in succession as the leaves fall: those nearest the machine, being the heaviest, is the gun-powder tea; the light dust the worst, being chiefly used by the lower classes. That which is brought down to Canton undergoes there a second roasting, winnowing, packing, &c., and many hundred women are employed for these purposes; the rate of pay being about fifty of their small copper coins, or fourpence *per* day. The Chinese say that the best tea is that which is gathered in the morning, while the dew is on. The gathering in the hyson countries, Kiang-nan and Fokien, commences about the middle of April, and continues till about the middle of May. The collecting, the rolling, the twisting, and roasting, give employment to a multitude of people. From the berry of the *tcha-wha*, or flower of tea *(Camelia sesanqua)*, a fine edible oil is extracted. The almond and the Palma Christi also afford them an oil for culinary purposes. The white wax is the produce of a tree, or rather of a small insect which frequents the tree; and the *Croton sebiferum* yields an excellent vegetable tallow; both of these articles serve them to make candles. In the southern provinces, sugar is a common article of cultivation; but it is rather a luxury than an article of common consumption. It is used mostly in a coarse granulated form; but for exportation, and for the upper classes, it is reduced to its crystallized state. Tobacco is universally cultivated, and in universal use, by all ages, and both sexes. Fruits of every kind abound, but mostly bad, except the orange and the *lee-tchee*, both of which are probably indigenous. The art of grafting is well known; but they do not appear to have taken advantage of this knowledge to the improvement of their fruits. They have also an art which enables them to take off bearing branches of fruit, particularly of the orange and peach, and transfer them, in a growing state, to pots, for their artificial rocks, and grottos, and summer-houses. It is simply by removing a ring of the bark, plastering round it a ball

China.

of earth, and suspending a vessel of water to drop upon it, until it has thrown out roots into the earth. It would require too much space to describe the various vegetable productions used for food and for clothing,—for medicine, and for the arts. The climate and the soil are well adapted for producing almost all that the rest of the world affords, except, perhaps, those parts which lie within a few degrees of the equator; and the Chinese have obtained their full share even of them.

They are exceedingly sparing in the use of animal food. Those important articles of milk, butter, and cheese, are wholly unknown to them. The broad-tailed sheep are kept in the hilly parts of the country, and brought down to the plains; but the two animals most esteemed, because they contribute most to their own subsistence, and are kept at the cheapest rate, are the hog and the duck. Whole swarms of the latter are bred in large barges, surrounded with projecting stages, covered with coops, for the reception of these birds, which are taught, by the sound of a whistle, to jump into the rivers and canals in search of food, and by another call to return to their lodgings. They are usually hatched by placing their eggs, as the ancient Egyptians were wont to do, in small ovens, or sand-baths, in order that the same female may continue to lay eggs throughout the year, which would not be the case if she had a young brood to attend. The ducks, when killed, are usually split open, salted, and dried in the sun, in which state they afford an excellent relish to rice or other vegetables.

The fisheries are free to all; there are no restrictions on any of the great lakes, the rivers, or canals. The subject is not once mentioned in the *Leu-lee;* but the heavy duties on salt render the use of salt fish in China almost unknown. Besides the net, the line, and the spear, the Chinese have several ingenious methods of catching fish. In the middle parts of the empire, the fishing corvorant, the *Pelicanus piscator*, is almost universally in use; in other parts, they catch them by torch-light; and a very common practice is, to place a board painted white along the edge of the boat, which, reflecting the moon's rays into the water, induces the fish to spring towards it, supposing it to be a moving sheet of water, when they fall into the boat.

When animal food fails them, the Chinese make no scruple in eating lizards, toads, grubs, cats, rats, mice, and many other nauseous creatures. The naked Egyptian dog is commonly exposed for sale in the market. But rice, the hog, and the duck, may be considered as the staple articles of human subsistence for the great mass of the population. Those who can afford it indulge in every species of luxury, and more especially in gelatinous soups, which, while they pamper the appetite, are supposed to excite the passions, and to increase their corpulency, which, in their ideas, confers a degree of respectability and dignity to which a small meagre figure can never arrive.

Commerce.

No country in the world is better adapted from situation, climate, and products, for extensive commerce, than China; yet no civilized country has profited less by those advantages. The happy distribution of its numerous rivers, aided by artificial canals, afford an almost uninterrupted water communication from the northern to the southern, and from the western to the eastern extremities of this grand empire; and thus a facility is given for the interchange of the products of one province with those of another, unknown in any other country, and unequalled even in Great Britain. But the commerce that exists is principally that of barter; no system of credit is established between the merchants of distant provinces; no bills of exchange; no circulating medium of any kind, as a common measure of value, excepting a small copper coin, of the value of the thousandth part of 6s. 8d., or about one-third of a farthing. The multitudes of barges of different sorts and sizes, which vary in their construction on almost every river, are incredible. The Chinese are rarely to be trusted where numbers are concerned; but they are probably not far amiss in stating that the number of imperial barges employed in the grand canal and its lateral branches, for the purpose of collecting and distributing among the public granaries the rice and grain paid in kind as taxes, amount to 10,000, or, as they express it, where they mean to be correct, to 9999. A vast number of vessels are also employed in conveying the copper currency from place to place, wherever it may be wanted; others in collecting the silks, cottons, and various articles of taxes, paid in kind, and depositing them in the public magazines; and the salt barges alone are probably not less numerous than those which carry grain. It was calculated that the depot of salt accumulated at Tiensing for the use of the capital and the northern provinces, was sufficient for a year's consumption for thirty millions of people. This was all brought up, in the course of the summer, from the sea-coast of Tchekiang and Fokien, in sea-going vessels. Cakes of coal-dust and turf, for fuel, and cakes made up of various ingredients for garden manure, employ a multitude of barges; and when to these are added the various kinds of vessels employed in general commerce, in the conveyance of passengers and baggage, in breeding ducks, and in the fisheries of the interior, we may be sure that the number of persons who constantly reside upon the water amounts to many millions, and are probably equal to the whole population of Great Britain. It may be doubted if these are included in any census.

All foreign commerce is systematically discouraged. The extent, fertility, and variety of their soil and climate, happily situated between the extremes of heat and cold, partaking of the advantages of both, without experiencing the inconveniences of either, supply the Chinese with the productions of almost all the world besides, whether to minister to the necessities, the comforts, or the luxuries of their numerous population; and leave this great empire, as a nation, completely independent of foreign supplies through the medium of commerce. Satisfied, or affecting to be satisfied, with the prodigal bounty of nature, jealous of strangers, governed by a gradation of arbitrary despots, the Chinese consider it as a favour bestowed on foreigners to open one of their ports for the interchange of commodities. The revenue derived from this limited intercourse is of little or no

importance at the chief seat of government. The largest estimate that can be made of the value of the whole of foreign commerce, and the largest computation of revenue flowing from it into the imperial treasury, is but as a drop in the ocean. Individual and local interests might and would most materially be affected by any prohibition of an intercourse which has now subsisted for a century and a half; but the government pays little regard to the prosperity or misery of a particular province. The interested views of individuals may, for a time, keep up a trade which is at variance with the general rule of policy prescribed by the laws; and the frequent discussions with the English, whose power they are aware of and dread, will most probably determine them ultimately to close Canton against all foreigners. The English they will not venture particularly to exclude, though they know that other nations would take their articles of produce without forcing upon them European broad cloths, which they affect not to want, but would give them specie, which is, of all other things, what they most desire.

The luxuries, however, which wealth requires, have forced a foreign trade by their own subjects with the nations of the east, as well as with Europe. A very extensive intercourse is carried on by them with Japan, the Phillipine Islands, Java, Sumatra, Timor, Gelolo, and the great island of Borneo, in all of which are found multitudes of Chinese living in habits of peaceful industry, in the midst of the more idle and less civilized natives, conducting the concerns of trade, cultivating the ground, and exercising all the various branches of the mechanical arts; in no place, however, varying in the smallest degree their original character. But though the Chinese spread themselves over every part of the Asiatic, and into many of the Polynesian Islands, there seems to be no reciprocity of commerce by the vessels of those countries visiting the ports of China, excepting some ten or twelve junks that annually visit the southern ports of Fokien from Japan, and perhaps as many from Cochin-China. "From Canton," says Lord Macartney, "to Ten-chou-foo, at the entrance of the Gulf of Pe-tche-lee (to say nothing of the country within the Gulf itself), is an extent of coast of near two thousand miles, indented with innumerable harbours, many of them capable of admitting the largest European ships, and all of them safe and sufficiently deep for the vessels of the country. Every creek or haven has a town or city upon it; the inhabitants, who abound beyond credibility, are mostly of a trafficking mercantile cast, and a great part of them, from their necessary employment in the fishery, which supplies them with a principal article of their subsistence, are accustomed to the sea, and the management of shipping." Yet with all these advantages, all foreign commerce in foreign bottoms is interdicted to these people; whatever they wish to import must be fetched by themselves; and the articles thus brought in are numerous and of considerable value. Thus from Java alone they import birds' nests to the value of half a million dollars annually. The sea slug or biche-da-mar *(holothuria)*, from the coast of New Holland, Timor, and adjoining islands, to a still greater extent—sharks' fins from the same quarter—copper from Japan, and tin from Bantam—pepper, areca nut, spices of different kinds, ebony, sandal wood, red wood for dyeing, tortoise-shell, pearl-shell, coral, camphor, wax, and a variety of articles, generally produced or collected by their own countrymen, resident on the islands of the east.

When Lange, who accompanied Ismaeloff, the Russian ambassador, asked permission for his nation to establish factories in all the provinces, the reply of the Emperor was, "I allow you to remain here (Pekin), and other foreigners at Canton, so long as you and they give me no cause of complaint; but if this should ever be the case, I will neither suffer you to remain here, nor them at Canton;"—so very indifferent does the Court affect to be about foreign commerce. In the whole of this extensive empire, there are but two places where the natives have any intercourse with Europeans,—at Canton with the crews of the several maritime powers, and at Kiackta with the Russians; and this intercourse is chiefly confined at the former to a select number of men, appointed or licensed by the government; at the latter it takes place only under special directions of the government itself, through merchants appointed under the seal of the Emperor. Of the instructions given to these merchants, the Russians procured a copy a few years ago, though the punishment for betraying them is condemnation to track the imperial barges for life; and a more singular document was never issued by any government. It confirms all that has been said of the meanness and knavery of this proud and insolent people; and as it has not before now appeared in print, a summary of it may prove amusing, and may serve to show, at the same time, the notions entertained by the Chinese with regard to the conduct of foreign commerce.

It sets out by stating that the aim of every nation, trading with other countries, is to prevent the advantage being on the side of the foreign nation; to do this the more effectually, and to establish harmony and frankness, "all the letters received by any one of the licensed merchants from their partners, are to be opened in a public assembly, that they may act in concert against the Russians." 2. That as the general principles of commerce require that prices and demands should be foreseen, means must be taken to ascertain what articles the Russians are in want of, and what prices they fetch in Russia; what supplies they may have or expect in the market, and what value they bear in Russia; every one is therefore to strive with all his might to get at this information, and lay it before a general meeting, when the president will give to each merchant a note of the quantities of each article, and of the prices he is to buy at, and of those articles which he is to withhold from the Russians. 3. That the Chinese market is to be kept scantily supplied, and Russian goods not eagerly sought, that the trade may be of importance to them, and the commerce advantageous to China. 4. That care be taken that the quantity of Chinese goods should appear always less than that of the Russians; and that no fresh goods be brought into the market before all the old stock be sold off. 6. That no eagerness be shown in the purchase of Russian goods, how much soever any in-

dividual of the merchants may be in want of them, "for the interest of the whole company is not to be sacrificed to that of an individual." 7. That when the Russians have a scanty supply of any article that may be likely to meet with a considerable demand in China, a great eagerness is to be shown to buy up the whole; the Russians are to be told that China is very much in want of the said article, and one merchant is to outbid the other, and, when bought, they are to divide the quantity among themselves. 8. That the Russians, thus tempted by the high prices, and the assurance given them of the great demand, will cause large supplies to be brought to market, when they are to be told that the article is no longer in request in China, &c. and thus the goods will be obtained at a cheap rate from the foreigners, to the great advantage of the whole nation. 9. Whenever the Russian merchants shall attempt to raise the prices of any commodity in consequence of its scarcity, every obstacle must be thrown in their way for the space of a month, and if they will not lower the prices, the whole trade must be suspended, and if, on complaint of the merchants, the Russian Government should interfere, it will not be attended to, and the answer will be, that the commerce between the two nations shall cease. The 10th article contains an impudent falsehood—it instructs them not only to tell the Russians that the quantities of the several articles on hand are much less than they really are, but that "China does not produce silk and cotton." The 11th article directs them to carry on all their intercourse in the Russian language, which every one engaged in the trade must learn in order to prevent the Russians from feeling the necessity of learning the Chinese language, and, by that means, "of discovering the secrets of the trade or those of the government" by overhearing conversations, &c. The 12th directs them to treat the Russians politely; permits reciprocal visits; but forbids a Chinese to pass a night in a Russian house; directs, that in these visits each should endeavour to learn something about the affairs of the Russian Government, and according to the importance of the information obtained, will be the value of the reward. The 13th directs, that a new merchant arriving at Mai-mai-chin, is not to do any business for a whole year, but merely to look on and learn the nature of the trade, "for fear he should, by some mistake, break the thread of the whole." The 14th and 15th prohibit gold and silver, manufactured copper and iron from being exchanged, and the introduction of all articles of luxury, of goods manufactured in China, and of wine and spirituous liquors. 16th, "The secrets of our trade in the interior as well as of that on the spot, must not be revealed, that this indiscretion may not occasion a rise in their prices, and a fall in ours, and thereby injure our empire and the trade of our subjects." The eight remaining articles prescribe the various punishments for disobedience of the foregoing instructions, from a reprimand to that of death. The 22d runs thus: "Whoever betrays to the Russians the secrets of our commerce in the interior, or the prices of Russian products in the interior, or the demand for them, the quantity he holds himself, or that others hold at Kiackta, or that may be on the road thither, shall be banished from Kiackta for ever, and be sent to the galleys for three years; but whosoever betrays to them *these instructions* verbally, or in effect, or by deed, shall be sent to the galleys for life." And by the 23d, "Whoever betrays the secrets of the government which are not to be known by the Russians, shall be beheaded, not, however, without the sanction of the Emperor." We know very little of the value of the trade carried on at this place in this extraordinary manner. It consists chiefly in exchange, on the part of Russia, of fur and various peltry, horses, drugs, &c. for tea, silks, nankeens, porcelain, lacquered ware, and other small articles similar to those imported by England. (From a Russian MS.)

The principal mart for foreign commerce is that of Canton, the only port, in fact, which is open for foreigners. For the last twenty years the foreign commerce of this port was almost exclusively in the hands of the English and the Americans. The English commerce consisted of two distinct branches; the one direct from England, and a complete monopoly of the East India Company; the other indirectly carried on by individuals from the several presidencies of India, chiefly from Bombay. The Chinese system of conducting their foreign trade at Canton, is somewhat different from that of Kiackta. It is a monopoly confided to a certain number of persons known by the name of Hong merchants; *hong* being the name of the large factories or masses of buildings surrounding square courts similar to our old inns, or the caravanseras of the East. Each nation has its separate hong, and the whole being arranged along the bank of a fine river, with a broad quay in their front, their appearance has a grand effect from the opposite side. The river is at least as broad as the Thames at London, and for the distance of four or five miles it is crowded by Chinese vessels of all descriptions, which, from the multitude of people constantly residing in them, may be considered as a floating city. Foreign vessels are not allowed to approach nearer to Canton than Whampoo, which is about fifteen miles down the river.

The Chinese levy no specific duties on the articles imported, nor *ad valorem* duties on the cargoes; the only impost is on the ship itself, and is estimated by a rule as absurd as it is partial and unequal. They measure the length from the centre of the foremast to the centre of the mizen-mast, and the breadth is taken close abaft the main-mast. The length is then multiplied by the breadth, and the product, divided by ten, gives the measurement of the ship. All ships, according to this measurement, are classed under first, second, or third rates; all other vessels, however small, are classed as third rates. By this rule a ship of 100 tons would pay from 4000 to 5000 dollars, and a ship of 1000 not above double that sum.

When a ship arrives at Canton, she is immediately consigned to one of the hong merchants, who is responsible to the government for the good conduct of her commander and crew during her stay in the river. Through his hands all her cargo must pass, and by him the return cargo must be supplied. By long experience of the honourable manner in which the servants of the East India Company conduct their concerns, a degree of mutual confidence has

been established, which is unknown even in Europe. Not a bale of cloth, nor a package of any kind, is ever opened to be examined, but is received and passed from hand to hand, the company's mark being a sufficient guarantee of its answering the description in the invoice; the same confidence prevails on our part; and though the Chinese attach no dishonour to roguery in trade, few packages of teas, silks, nankeens, or other articles, are received in England which are not conformable with the samples. This, however, was not the case originally, nor is it so yet in purchases made by individuals; but as the hong merchants take back any article not answering to the description given of it, and return it to the person who supplied the same, the inducement to cheat the Company is taken away. Some of the hong merchants accumulate fortunes which, for their magnitude, are unknown in Europe; others become bankrupt, in which case, as they are all appointed by government, the rest find it expedient to compound with their creditors, and, by such arrangements as may mutually be agreed upon, undertake to liquidate, by instalments, the whole debt. At the close of every season there is generally a balance in the hands of the hong merchants due to the East India Company, from half a million to a million Sterling, and as much more due to individuals trading on their own bottoms. The hong merchants plead the necessity of retaining this balance, in order to enable them to make advances to the tea growers, silk and cotton manufacturers, &c. who, as in India, are persons of small capitals, and require these advances to raise their respective products.

The articles exported by the East India Company consist of broad cloth, long cloths, camblets, furs, lead, tin, copper, &c. but the chief article is broad cloth, the annual export of which at this time is not far short of one million Sterling; the amount of the remainder may be L.200,000 or L.300,000. The commanders and officers of the Company's ships have the privilege of taking out certain articles, such as peltry, glass, clocks, watches, cutlery, coral, prints, and paintings, &c. to the amount of about L.200,000.

The principal article of import from China is tea. Of this article England alone takes from 24,000,000 to 30,000,000 pounds weight annually. The rest of the cargo consists of nankeens and raw silk. The minor articles of porcelain, lacquered and ivory goods, tutanague, mother of pearl, drugs, cinnabar, &c. are chiefly confined to the private trade. The cost and charges of the total imports in the Company's ships from Canton amount to about L.3,300,000, and the sales amount to about L.4,200,000. The continuance of the China trade is therefore of the utmost importance not only to the East India Company, but to the nation at large. It enables the East India Company to pay its dividends, without which, in its trading capacity, it must immediately become bankrupt; it pays into the revenue at least L.3,500,000 annually; it employs about 20,000 tons of shipping, and 2000 seamen: and it supplies an article of consumption which no other part of the world can supply, and which has now become an article of almost universal use; and it takes off one of the staple commodities of England, to the value of nearly L.1,000,000 Sterling. For many years the balance of trade with England was greatly in favour of China, and required large sums of specie to be sent out annually; but towards the conclusion of the war, when it was most difficult to be procured, when it was most wanted at home, and when its value was greatly increased, England most fortunately drew through India a balance in bullion from China: and thus the Indian commerce with the port of Canton became of the utmost importance to the mother country, as well as to the resident merchants of that distant possession of the East India Company.

The commerce of India with China is chiefly carried on from the two presidencies of Bombay and Calcutta; and it has been stated that the most moderate estimate of the value of tonnage and merchandise necessary for the present extent of this trade is upwards of L.2,200,000 Sterling, exclusive of pearls, sandal-wood, peckhuck, and other inferior articles; and of the pepper, betel nut, rattans, &c. from the east coast and the islands. Bombay is most favourably situated by its geographical position for carrying on an active commerce, and for the employment of a numerous population. The cotton of Guzzerat and the neighbouring countries supplies all that China can take, and a surplus for England; and the imports from China are conveniently distributed along the shores of the Persian and Arabian Gulfs, the northern ports of Guzzerat, and the dominions of the Peishwa. Of late years, the balance in favour of India was drawn from China in the shape of bullion. About three years ago, when, from some misunderstanding with the Chinese, the servants of the East India Company found it expedient to stop the trade of the country ships till the impediments thrown in the way of the direct trade should have been removed, the merchants of Bombay sent a memorial to the Board of Control, and a petition to the House of Commons (neither of which, however, were presented), in which the capital and tonnage embarked in the China trade is thus stated:

Annual Export of Cotton.

	Rupees.
Sent by individuals, at least 100,000 bales or 50,000 cundies, of 784 pounds each. In measurement, 4 bales or 2 cundies are equal to 1 ton; so that, for the cotton alone, 25,000 tons of shipping are required, the value of which is - - -	50,00,000
The average price of cotton on board ship, is not less than 140 rupees *per* cundy, and the value is -	70,00,000
The charges of transit to China, at 40 rupees *per* cundy, is - -	20,00,000
Of the quantity of opium annually sold at the Company's sales in Calcutta, at least 2500 chests may be assumed as the quantity exported to China in British ships, which, at 1700 rupees *per* chest, amounts to	42,50,000
Making a total value of rupees	1,82,50,000

China.

The Chinese appear to have no regular established system of credit among themselves, and the only circulating medium in the shape of coin, is a small piece of base metal (copper, tin, or lead mixed), of the value of the one-thousandth part of six shillings and eightpence, of little more intrinsic value, in fact, than a cowrie shell, which the Chinese, as well as the Hindoos, would seem once to have used; as the same character in their language which signifies a *shell* signifies also money and wealth; and it enters into the composition of characters which represent *buying, selling, paying*, &c. Silver in small ingots is used in commerce, but they have no determinate value, the price fluctuating with the demand, as in other articles of commerce. The high rate of interest operates as a discouragement to mercantile speculations, and the rigour of corporal punishment is added with the view, as it would appear, of deterring the most hardy speculator. The law says, "whoever shall lend either money or goods, shall only receive three parts in the hundred *per* month," and that "how much soever may be suffered to accumulate, the capital shall remain the same." It is lent from month to month, and if the lender should complain of the interest not being punctually paid, the borrower is subject to the punishment of ten stripes of the bamboo the first month, twenty the second, and so on. While this exorbitant rate of interest, and the penalties attached to the law of usury, operate against all speculation among the Chinese, the Europeans, resident at Canton, have availed themselves of the opportunity of increasing their fortunes at the expence of the Hong merchants, and at the risk of losing both capital and interest. (*From various MS. papers.*)

General appearance of the Country.

When an European first sets his foot in China, he will find the appearance of the country, the buildings, and the people, so totally different from any thing he had before seen, that he might fancy himself to be transported into a new world. In the long line of internal navigation between the capital and Canton, of 1200 miles, with but one short interruption, he will observe every variety of surface, but disposed in a very remarkable manner in great masses; for many days he will see nothing but one uniform extended plain, without the smallest variety; again, for as many days, he will be hemmed in between precipitous mountains of the same naked character, and as unvaried in their appearance as the plains; and, lastly, a ten or twelve days sail among lakes, swamps, and morasses, will complete the catalogue of monotonous uniformity; but whether he crosses the dry plains of Petcheli and Shantung, abounding with cotton and all the varieties of grain and pulse,—the more varied surface of Kiang-nan, fertile in silk, in yellow cotton, in fruits, in the staple commodity of grain, and in every thing that constitutes the luxuries, the comforts, and the necessities of the people,—the dreary swamps, morasses, and extensive lakes of the northern part of Kiang-see, where men subsist by fishing,—or its naked and picturesque mountains to the southward, famous for its porcelain manufactories,—or whether he descend to the fertile plains of Quan-tung, on which almost all the vegetable products of the East may be said to be concentrated, the grand characteristic feature is still the same—a redundant population. Every where he meets with large masses of people, but mostly of one sex; thousands of men in a single group, without a single woman mixing among them,—men whose long gowns and petticoats give them the appearance of the softer sex, while these are sparingly seen at a distance in the background, peeping over the mud-walls, or partially hid behind trees or bushes; whose short jackets and trowsers would make them pass for men among strangers, if their braided hair, stuck full of flowers, and their little cramped and bandaged feet, did not betray their sex. He will be pleased with the unequivocal marks of good humour which prevail in every crowd, uninterrupted and unconcerned by the bawling of some unhappy victim suffering under the lash of magisterial correction; and he will be amused at the awkward exertions of the softer sex to hobble out of sight, when taken by surprise; but his slumbers will be interrupted on the nights of the full moon by the nocturnal orgies of squibs and crackers, gongs and trumpets, and other accompaniments of boisterous mirth.

A constant succession of large villages, towns, and cities, with high walls, lofty gates, and more lofty pagodas, large navigable rivers, communicating by artificial canals, both crowded with barges for passengers, and barks for burden, as different from each other, in every river and every canal, as they are all different from any thing of the kind in the rest of the world,—will present to the traveller an animated picture of activity, industry, and commerce. He will behold, in the lakes and morasses, every little islet crowned with villages and mud hovels. He will observe birds (the leu-tse, or cormorant) catching fish; and men in the water, with jars on their heads, fishing for birds. He will see shoals of ducks issuing from floating habitations, obedient to the sound of a whistle; carts on the land, driven by the wind; and barges on the water, moving by wheels, like those recently *invented* in Europe for propelling the steam-boats. Among other strange objects, he will observe, at every ten or twelve miles, small military guard-houses, with a few soldiers fantastically dressed in paper helmets and quilted petticoats, making use of the fan, if the weather be warm, and falling on their knees, if an officer of rank should pass them.

He will observe that the meanest hut, with walls of clay, and a roof of thatch, is built on the same plan, and of the same shape, with the palace of the viceroy, constructed of blue bricks, and its tiled roof supported on pillars. He will notice that the luxury of glass is wanting in the windows of both; and that, while one admits a free passage to the air, the other but imperfectly resists the weather, and as imperfectly admits the light, whether through oiled paper, silk gauze, pearl shell, or horn.

Nothing, perhaps, will more forcibly arrest the attention of the traveller than the general nakedness of the country as to trees and hedge-rows, of which the latter have no existence, and the former exist only in clumps near the dwellings of the public officers, or the temples of Fo, or Tao-tse. No green meadows will meet his eye; no cattle enliven the

scene; the only herbage is on the narrow ridges which divide the plots of grain, or the brown fallow, as in the common fields of England. The terraced hills he will probably observe to be terminated with a clump of trees, or a pagoda,—the only objects in the distance that catch the eye. But the bridges on the canals, of every variety of shape,—circular, elliptical, horse-shoe, gothic,—slight and unstable as they are, are objects that, by their novelty and variety, must attract notice; and the monumental architecture, which adorns the cemeteries under every form, from the lowly tent-shaped dwelling to the loftiest column,—the elevated terraces, supported by semicircular walls,—and the round hillocks, which, in their graduated size, point out that of the father, the mother, and the children, according to seniority,—are among the most interesting objects that China affords.

If, by chance, he should be admitted within the gates of one of their great cities, as Pekin, Nankin, Sau-tcheou-foo, Hang-tcheou-foo, or Canton, he may fancy himself, from the low houses with curved overhanging roofs, uninterrupted by a single chimney, the pillars, poles, flags, and streamers, to have got into the midst of a large encampment. The glitter arising from the gilding, the varnishing, and the painting, in vivid colours, that adorn the front of the shops,—and, in particular, the gaily painted lanterns of horn, muslin, silk, and paper,—the busy multitude all in motion, and all of one sex,—the painted and gilded inscriptions that, in announcing the articles dealt in, assure the passengers that "they don't cheat here,"—the confused noise of tinkers, cobblers, and blacksmiths, in their little portable workshops,—the buying, selling, bartering, and bawling, of different wares,—the processions of men carrying home their new-married wives, with a long train of presents, and squalling and noisy music; or carrying to the grave some deceased relation, with most lamentable howlings,—the mirth and bursts of laughter occasioned by jugglers, conjurors, mountebanks, quack-doctors, musicians, and comedians; in the midst of all which is constantly heard a strange twanging noise from the barbers' tweezers, like the jarring sound of a cracked Jew's harp,—the magistrates and officers, attended by their lictors, and a numerous retinue, bearing flags, umbrellas, painted lanterns, and other strange insignia of their rank and office;—all these present to the eyes and ears of a stranger a novel and interesting spectacle. The noise and bustle of this busy multitude commence with day-light, and cease only with the setting of the sun; after which, scarcely a whisper is heard, and the streets are entirely deserted.

Towards the central parts of China, near to the places where the two great rivers, the Whang-ho and the Yang-tse-kiang, intersect the Grand canal, a scene, magnificent beyond description, will arrest the attention of the traveller; here he will find himself in the midst of bustle and business. The multitude of ships of war, of commerce, of convenience and of pleasure, some gliding down the stream towards the sea, others working against it by sails, oars, or wheels, and others lying at anchor; the banks on either side, as well as those of the canals, covered with towns as far as the eye can reach; the continuance along the canals of cities, towns, and villages, almost without interruption,—the vast number of light stone bridges, of one, two, and three arches,—the temples occurring in frequent succession, with their double and triple tiers of roofs,—the Pei-los, or triple gateways, in commemoration of some honest man or chaste virgin,—the face of the surrounding country, beautifully diversified with hill and dale, and every part of it in the highest state of cultivation,—the apparent happy condition of the numerous inhabitants, indicated by their cheerful looks and substantial clothing, chiefly in silk,—such are the scenes which presented themselves to our countrymen who composed the embassy of the Earl of Macartney, and were recently repeated to those who accompanied Lord Amherst.

He would probably be mistaken, however, in inferring the general happy state of the people, or beautiful appearance of the country, from what might occur along this great line of communication between the northern and southern extremities of the empire. The Dutch embassy setting out in winter, when the canals were frozen, proceeded by a different route, and the inconveniences they suffered, as described by Van Braam, and in a MS. *Journal* in our possession, are such as can scarcely be credited to have occurred in any nation removed but a few degrees from the savage state: The face of the country was dreary, without a visible trace of cultivation, or a hovel of any kind, for the space of eight or ten miles together. In many parts the surface was covered with water, and the mud hovels completely melted down. Very few cities, towns, or villages, occurred in their route, and those were almost universally in a ruinous condition. Near to the capital they passed a city exhibiting only a mass of ruins. It was not before they had crossed the Yellow River that the prints of wheel-carriages marked out the road. The people every where appeared indigent and oppressed, equally destitute of the feelings of humanity and of hospitality. The Dutch were carried in small bamboo chairs, each having four bearers, so weak and tottering that they could seldom go through the day's journey; and it frequently happened that they halted in the middle of a cold night, in an open uninhabited part of the country, exposed to all the inclemency of the weather, without a hovel of any kind to afford them shelter; and when they reached the end of the day's journey, the lodgings appropriated for their reception were so miserable, admitting, on all sides, the wind, rain, or snow, that they generally preferred taking a little rest in their bamboo chairs. They observed on the road old men and young women travelling in wheel-barrows, sometimes in litters or chairs carried by a couple of asses, one being fixed between the poles before and one behind. The rivers were without bridges, and crossed, when not fordable, by rafts of bamboo.—All this is corroborated in a subsequent publication of *Voyage à Peking*, by M. de Guignes; and hence it may be concluded, that China, like other countries, has its fertile and its desolate districts, and that much information is yet required to form a competent no-

China.

tion of the real state and condition of this mighty empire.—(Staunton's *Authentic Account.*—Lord Macartney's *Journal.*—Barrow's *Travels.*—*Voyage à Pekin.*—Van Braam's *Journal.*—MS. *Journal.*)

Ornamental Gardens.

One thing, at least, is quite certain, that a traveller in the best and most frequented parts would look in vain for the least trace of those enchanting gardens of which Sir William Chambers and his friend, Lepqua, the painter of Canton, aided by another brother of the brush, Frere Attiret, Jesuit and painter to the Emperor of China, have put together so fanciful a description. Sir William saw, what Europeans generally see in Canton, the shops in China-street, the quay, on which the foreign factories are situated, and, perhaps, a small mean garden, at the head of the first reach of the river, to which strangers are permitted, as a great favour, to go and buy parcels of lettuce and turnip seeds neatly packed up and sold as rare and curious flowers; and the French Jesuit's taste and accuracy may be estimated from his own statement, that " the face of the country from Canton to Pekin is very indifferent; and though six or seven hundred leagues (it is four hundred) nothing occurs worthy of attention." He tells us, it is true, that he was shut up in a kind of close cage, which they laboured to persuade him was a litter, and that he arrived in Pekin without having seen any thing at all on the journey.

With the exception of the imperial gardens of Gehol and Yuen-min-yuen, there is not, perhaps, in all China a piece of ornamental ground of the extent of three acres; and a traveller may pass the whole distance in the open air, which Frere Attiret did in his cage, without seeing a single one of any extent. If he should chance to get a peep within the enclosing walls of those lodges set apart for the residence of the Emperor when he travels, or of the habitation of some magistrate or wealthy merchant, he will probably find a square court of a rood or two of ground behind the women's apartments, concealed completely from public view, in which two or three little fish ponds have their margins fantastically broken by shapeless masses of rock, or cut so as to resemble rugged mountains in miniature; among which, planted in concealed earthen vessels, are dwarfish trees proportioned in size to the pigmy mountains, and bearing all the marks of venerable age; causing new roots to strike in old branches, twisting and bending them into particular forms and directions, wounding the stem, and smearing it with sugar to attract the ants and other insects. Among these rocks are narrow paths almost impassable, with holes and crevices here and there to peep through, just to catch a glimpse of some piece of stagnant water, on the shore of which is a wooden temple, a bridge, a pavillion, or perhaps to view a remarkable piece of rock. Within the water, if large enough, an island with its pagoda will probably be placed; or, as occupying less space, the imitation of a passage boat stuck upon piles, and fitted up with appropriate apartments, kitchen, &c. In the recesses of the rocks are seats or small summer houses, opposite to which are parterres of various flowers growing in sunken pots, which can thus be replaced by others in bloom, according to the season of the year; and where there is space, the peach, the orange, the Lee-tehee, and other fruit trees, are introduced. From the boundary wall, a roof is generally projected, supported on wooden pillars, which forms a covered gallery to walk in; gravel walks are out of the question, and would be wholly inconsistent with the feelings and usage of a nation, the women of which, for whose recreation these gardens are chiefly designed, cannot walk, and whose male population, of the upper ranks, are too indolent to walk. In short, where secrecy is so desirable, where enjoyments are stolen, and walking is considered as drudgery, seats and concealed recesses are best suited to the comfort and the convenience of the people. If a Chinese acts on any principle, it is that of producing the greatest possible variety in the least possible space. He is indebted to nature for many of the most beautiful shrubs and flowers which she has bestowed on man for the gratification of the sense of sight or smell. Various species of camelia, pœonia, chrysanthemum, asters, roses, and a numerous list of the choicest flowers, gratify the eye, while the *Pergularia odoratissima*, the *Olea fragrans*, the *Petrosporum Chinense*, and the Arabian jessamine, spread their fragrance around. The sacred Nelumbium breaks the surface of the water with its peltate leaves and showy flowers, and the elegant bamboo, and the water cypress (*Cupressus pendula*), like the weeping willow, give concealment to their seats of retirement, whether for ease or sensuality.

General View of Customs and Character.

Throughout this extensive empire, embracing so great a variety of climate, the physical and moral characters of the people remain as fixed and unchangeable as the laws and customs, from which, in fact, they receive their colour. Such is the force of ancient usage and the dread of innovation, that a Chinese never stops to inquire what he ought to do on any pressing emergency, but what Yao and Chun did in a similar case four thousand years ago. Time, in fact, may be said to stand still in China. Here not only the system of morals, of social intercourse, of jurisprudence, of government, is the same now as it was three thousand years ago, but the cut of their robes, their houses and furniture, are precisely the same; so that if custom has exercised its dominion over this singular people, they have at least been freed from the tyranny of fashion. Here a young lady may safely wear the head-dress of her great-grandmother, without the imputation of being singular or old fashioned. One of the Missionaries observes, *Parcourez l'empire de la Chine; tout vous semblera fondée dans le même creuset, et façonné par le même moule.* No fault can be found with the metal or the mould in which it is cast. The general stature of the Chinese is about that which, in Europe, we call the middle size; few tall men are to be found among them; fewer dwarfs and deformed persons, but they are distinguished by many physical peculiarities; as the narrow, elongated, half-closed eye, the linear and highly arched eye-brow; the broad root of the nose; the projection of the upper jaw a little beyond the lower; the thin straggling beard, and the body generally free from hair; a high conical head and triangular face; and these are the peculiar characteristics which obtained for them

in the *Systema Naturæ* of Linnæus, a place among the varieties of the species distinguished by the name of *homines monstrosi*.

Every individual, without exception, plaits his strong black hair into a long tail, something like the lash of a whip, extending below the waist, sometimes to the calf of the leg: this tail grows from the crown of the head, the rest of the scalp being closely shaven; the hair of the beard is pulled out till nearly the age of forty, when its growth is encouraged, and being an indication of age, is considered as a mark of respect. The great mass of the people is decently and substantially clothed; the upper and middle classes in rich silks, satins, and fine cottons, the lower orders generally in cottons; but they are not cleanly in their persons; having, apparently, a particular aversion from cold water, which they never use in its pure state as a beverage, and always warm it for washing the hands and face, even in the middle of the dog-days; yet they use ice in the northern provinces for cooling their fruits.

The countenance of a Chinese man has something in it peculiarly pleasing and good humoured, which is just the reverse with that of the women, at least with those in the common rank of life, the only women who are seen in public. A Chinese is only out of humour when disturbed at his meal; necessity only, not even his own self-interest, will prevail on him to leave his rice unfinished.

The common people seldom sit down to table, nor, in fine weather, take their meals within doors; but each with his bowl in his hand, squatting himself down on his haunches round the boiler, eats his frugal repast of rice or other vegetables, seasoned with a little pork or fish; or salted duck, with oil, fat, or a little soy; washing it down with weak tea, or warm rice beer, or *seau-tcheou*, a villanous ardent spirit. Rice is the staff of life in China, of which they eat largely, but in drinking they are extremely moderate. They are not nice in their choice of food,—dogs, cats, rats, and almost every animal being eagerly sought after by the poorer class. In such a mass of population, many families must necessarily struggle with all the ills of extreme poverty; fewer, however, it would appear, in proportion to the population, than in most other countries; the small imposts on agricultural produce, the easy terms on which land is procured, the small divisions into which it is partitioned out, the multitude of large rivers, lakes, and canals abounding with fish, the freedom of the fisheries, and the extremely moderate rate at which the agricultural and labouring poor are taxed, are so many spurs to industry; and when a man through age or infirmity becomes incapable of labour, his relations are compelled to contribute to his support; a refusal would be an offence against parental affection, which is not in China a mere moral maxim, but carries with it the force of a positive law; poor houses are consequently scarcely known, and beggars exist only in the persons of the priests of Fo and Tao-tse and other impostors, in the shape of astrologers and fortune-tellers. Old age is here highly respected, and the imperial family takes every occasion to set the example. On Yung-chin's marriage with a Tartar princess, she distributed a piece of cotton cloth and two measures of rice to every woman throughout the empire whose age exceeded 70 years. In the province of *Shan-tung* alone, whose population may amount to 20,000,000, the list consisted of 98,222 above 70; 40,893 above 80; and 3453 above 90 years of age.

In all ranks of life, but more especially among the magistrates and officers of government, vivacity and activity are less esteemed than sedateness and deliberation; gravity is considered as the test of wisdom, and silence of discretion. A magistrate should never attempt to joke, and should forbear to talk; he should resemble great bells which seldom strike, and full vessels which give little sound. He should never show his anger, as this would put the person who had offended him on his guard. A Chinese of education is a complete machine; he must act and speak and walk abroad, dress, receive and return visits, according to rule founded on ancient usage; the observance of which is a most important part of his duty. If two persons meet, they know from the button on the bonnet their respective ranks, and that alone determines what each has to do and to say. If two officers of equal rank pass each other, they fold their hands and salute each other till out of sight; if of different ranks, the chair or carriage of the inferior must stop while that of the superior passes, and where the difference is very great, the inferior must alight. It is not, as in Europe, that one person may pass another with indifference, may take off his hat or keep it on, may give or refuse his hand, according to the humour in which he may happen to be; if one of the people should fail to pay the respect that is due to their superiors, a few strokes of the bamboo will bring him back to a sense of his duty. Where there is so much ceremony, there must be much hypocrisy and little cordiality.

When one officer pays a visit to another, a sheet of red paper, folded in a particular manner, bearing the name and quality of the visitor, is dispatched before him, that the person visited may know where to receive him, at the gate, in the first court, or in the inner apartment. The card is accompanied by a list of presents meant to be offered. If part be received, a letter of thanks, and a list of those returned, is sent back, with this observation in two characters, "they are pearls, I dare not touch them," in allusion to the prohibition of pearls being worn by any except the Imperial family, or those who have special leave. The visits of an inferior must always be made before the first meal, that the fumes of meat or wine may not offend the person visited. If he means to decline the visit, the bearer of the card is desired to say to his master, that he will not give him the trouble to alight from his chair; but if he does not return the visit in person, he sends his card within three days, and there the visiting acquaintance ends. Where a visitor is received, a prodigious deal of bowing and ceremony takes place. When once seated, to lounge on the chair, to lean back, to sit cross-legged, or to throw about the arms, or to look round, would

be a gross breach of good manners. A cup of tea, sipped simultaneously, according to rule, finishes the formal visit.

These restraints of ceremony, imposed more or less on all conditions of men, are incompatible with frankness and sincerity, and beget that want of confidence between colleagues in office, which is particularly observable in this jealous government, by the constant plotting against and undermining each other. The habitual gravity which a magistrate must put on in public, stamps an air of importance on matters of the most trifling nature, though it is said they sometimes relax in private, where they indulge in all manner of excesses, and the stiff formality which strongly characterizes this people, is said to give way, on such occasions, to conviviality; not, however, unless they are well acquainted with their guests. At such feasts, women never appear, but are usually left to be amused by a set of players. To convince the guests how anxious the entertainer is to see them, the invitation is repeated three several times, the first on the preceding evening, the second on the morning of the day, and the third when dinner is ready for serving up, which is the latter of the two meals, and generally from four to six o'clock, according to the season of the year. The guests do not sit down at one table, but generally in pairs at small square tables, every one of which is served precisely with the same kind of dishes, which are very numerous. Besides the ordinary quadrupeds, birds and fishes, used as food, several gelatinous articles, as bears' paws, the hoofs of various animals, stags' sinews, sharks' fins, birds' nests, biche da mer, fucus or sea weed, enrich their soups. With these and other substances mixed with spices, and soys and various herbs, they have an endless preparation of dishes, served up in small porcelain bowls, eaten with porcelain spoons, and two little ivory or ebony sticks, with which they take the pieces of meat or dry rice, and throw them into the mouth. Pastry and sweatmeats are served up at intervals; tea follows the dinner, after which comes the desert. Those who, from illness or accident, send an excuse, have their portion of the dinner sent to their homes. Each guest, the next morning, sends a billet of thanks for the good fare he enjoyed the preceding evening.

Though there are tea houses and cook-shops to which tradesmen, artisans, and the peasantry, with the inferior officers of state and clerks of the departments, occasionally resort to refresh themselves, and to read the Pekin Gazette, there are no promiscuous assemblies or fixed meetings, as fairs for the lower classes, or routes, balls, or music parties for the higher ranks. Dancing is utterly unknown. The clumsy boots of one sex, and the crippled feet of the other, would be ill adapted for the amusement of dancing, even were the sexes permitted to mix together; but "tripping on the light fantastic toe" would not become that gravity which is so essential in the exterior of Chinese good breeding. In the former Tartar dynasty, some Lamas from Thibet brought with them to Court a set of dancing girls, whose lascivious movements gave great offence to the grave and virtuous Chinese, whose general conduct towards the women is nearly as bad as that which prevails among savage tribes. One may discover in their proverbs the feeling toward the sex. "A family," it is said, "in which there are five women, has nothing to fear from robbers; its poverty will protect it." Again, "When the hen crows in the morning, domestic affairs are not going on as they should be,"—and, "What the women have lost in their feet, they have added to their tongues."

It is remarkable enough that the accurate Marco Polo is wholly silent on the subject of the crippled feet of the Chinese women, which there can be no doubt were as common in his time as they are now. Of the origin of this unnatural custom, the Chinese relate twenty different accounts, all equally absurd. Europeans suppose it to have originated in the jealousy of the men, determined, says Pauw in his severe manner, to keep them "si etroit qu'on ne peut comparer l'exactitude avec laquelle on les garde, qu'à la sévérité avec laquelle on les gouverne." Whatever may have been the cause, the continuance may more easily be explained—as long as the men will marry none but such as have crippled feet, crippled feet must for ever remain in fashion among Chinese ladies. It is kept up by the pride of superiority and the dread of degradation, like the custom of widows burning themselves in India.

The little value set upon females leads but too frequently to that unnatural crime, female infanticide and exposure. There can be no question as to its existence; the extent of it, however, may have been exaggerated. In the Pekin Gazette of 1815 is a representation from a humane magistrate of Kiang-nan to the tribunal of justice in the capital, praying that the horrible practice of selling and putting away wives, and drowning female infants, may be prohibited: on which the emperor Kia-king sagaciously observes, that "the existence of male and female is essential to the continuance of the human species,"—that "husband and wife form one of the five relationships in which human beings stand to each other,"—that "divorce is not allowable, except for one of the seven causes,"—and concludes, "if it be true that it is a common practice among poor families to drown their female infants, and the husband and wife separate for every trifle, these are indeed wicked practices, which should be put a stop to by admonitory and prohibitory edicts." The magistrates of a district of Fokien sent a case to court on another occasion to know how they should act. It was this: A man had made a vow, that if his wife recovered from a fit of sickness, he would make a sacrifice of his son, who was three years of age. The wife recovered, and he performed his vow. The supreme court decreed, that, having violated the laws of nature, he had incurred the penalty of death; but, on a mistaken notion that, by the unnatural sacrifice, he had saved the life of the mother, the emperor mitigated the punishment to 100 blows of the bamboo, and perpetual banishment.

This is but a miserable picture of the state of society in China. It is rendered still worse by the common practice of all oriental nations, which admits of a man taking as many wives as he can maintain. In China, a second or inferior wife is taken without any ceremony, and generally purchased; the children by her are considered as the children of the first wife, and strictly

legitimate; but the mother is without consideration in the eye of the law, and may be disposed of in the same way as she was procured.

The athletic exercises of wrestling, boxing, fencing, the active amusements, such as cricket, golf, bowls, tennis, are wholly unknown, and the sports of the field, as hunting, shooting, angling, as pursuits of pleasure, cannot be conceived by them. The Tartars, however, are fond of hunting, of the pleasures of which the Chinese had so little idea, that Kien-lung, in his *Eloge de Moukden*, seems to think it necessary to acquaint them with the benefits arising from this diversion. Having described the pleasures and the dangers of the chace, "Thus," says he, "ends this delightful and highly useful exercise, which is at once propitious to heaven, to the earth, and to the army; to heaven, by the offerings it affords in its honour; to the earth, which it relieves from the cruel and pernicious guests that prey upon it; and to the army, by accustoming them to the dangers and fatigues of war."

To appear with the head uncovered, and without boots, would be an act of rudeness not to be tolerated. To receive a present with one hand would be equally rude and disrespectful; to mention the word *death* would be an insufferable rudeness. When a person dies, he is said to be gone to his ancestors. Many other peculiarities might be mentioned, in which they differ from the rest of the world, and many in which they resemble the Turks in a very marked manner; but this is the less surprising, as the Turks are from the same Scythian stock.

Suicide is no crime with the Chinese. It is a favour to a condemned criminal to allow him to be his own executioner. Women, and officers of the government, are most addicted to the practice of suicide; the former, perhaps, from a sense of degradation, or in the gloom of solitude; the latter possibly to escape torture or disgrace, when suspected of criminal conduct.

There are two favourable traits in the Chinese character which should not be overlooked—the respect and veneration of children for their parents, and the almost universal sobriety that prevails in all ranks and conditions of men. A curious story is told by Le Gentil, which he had from P. Laureati, respecting the Emperor Kaung-he, who, one day, determined to experience the unknown pleasure of getting drunk. He chose his favourite minister as his bottle companion, who contrived to keep sober while his master was unable to stand. The minister apprized the chief eunuch of the emperor's situation, and hinted that if they did not contrive to cure him of the practice, none of their lives would be safe for a moment—"you must, therefore," he continues, "load me with chains, and throw me into a dungeon." Kaung-he, on waking, inquired for his companion; the eunuch said that he was in confinement by his orders, for having incurred his displeasure. The emperor doubted his senses, but, having ordered the minister to be brought before him, he was so shocked and provoked, that he never afterwards ventured to repeat the experiment.

Like other nations, therefore, the Chinese character has its bright as well as its dark side, and, if we find the latter to be the most prominent, it should be remembered that it is drawn chiefly by foreigners, and principally by those whose communication is rare and restricted, or by those who have only visited one of their out-ports, distant many hundred leagnes from the seat of government. Here, by all accounts, they are so much given to knavery and cheating, that it is held to be no crime in the seller to cheat, where the buyer is stupid enough to be cheated. Pauw observes, that the shopkeepers would never have thought of writing upon their signs, "here nobody will be cheated," if they had not predetermined to cheat all the world; yet our own shopkeepers are not backward in announcing their "genuine" articles. It is to be feared, however, that the boasted morality of the Chinese is built on no principle of feeling or propriety of action between man and man; and that, where public decorum is not offended, there is no breach of moral duty. Great crimes are not common, but little vices pervade all ranks of society. A Chinese is cold, cunning, and distrustful; always ready to take advantage of those he has to deal with; extremely covetous and deceitful; quarrelsome, vindictive, but timid and dastardly. A Chinese in office is a strange compound of insolence and meanness. All ranks and conditions have a total disregard for truth; from the emperor downwards, the most palpable falsehoods are proclaimed with unblushing effrontery to answer a political, an interested, or an exculpatory purpose. The present emperor asserted, and several great officers of state repeated the assertion, to Lord Amherst, that they *saw* Lord Macartney go through the whole of their odious ceremony, and that he performed it to admiration.

These are among the dark shades of the Chinese character, opposed to which may be set his sober and industrious habits,—submissive disposition,—a mild and affable manner,—an exactness and punctuality in all which he undertakes to perform; and if he has not been taught a general philanthropy, or if sentiments of love for the whole species have not been instilled into his mind, he has at least the merit of believing in the God of his fathers,—in obeying the commands of his superiors,—and of honouring his father and mother. Under a better government the Chinese could not fail to become a better people; as it is, some favourable traits may be found, both in the habits of the people and the principles of the government. "Some very considerable and positive moral and political advantages," as Sir George Staunton observes, "are attributable to the system of early and universal marriage; to the sacred regard that is habitually paid to the ties of kindred; to the sobriety, industry, and even intelligence of the lower classes; to the almost total absence of feudal rights and privileges; to the equable distribution of landed property; to the natural incapacity and indisposition of the government and people to an indulgence in ambitious projects and foreign conquests; and, lastly, to a system of penal laws, if not the most just and equitable, at least the most comprehensive, uniform, and suited to the genius of the people for whom it is designed, perhaps of any that ever existed;"—and with this qualified character we dismiss the subject. (K.)

THE 214 ELEMENTS OR KEYS

ELEMENTS OF I STROKE

一 ye *one; alone, the chief, the same.*
丨 quan *straight; perpendicular.*
丶 choo *a point; anciently a chief.*
丿 pei *bent outwards; to arrive at.*
乙 ye *crooked; interupted, one of the characters of the cycle.*
亅 quay *to drag with a hook; hooked.*

OF II STROKES

二 ul *the numeral* two.
亠 too *the summit or top of any thing.*
人 jin *a man; mankind.*
儿 jin *the ancient character for man.*
入 jee *within; to enter to obtain.*
八 pa *the numeral* eight; *opposite.*
冂 keong *a desart; far distant.*
冖 mee *to cover; the roof of a house.*
冫 ping *cold; frost an icicle.*
几 kee *something to support another; the legs of a stool.*
凵 kang *a cavern; a cavity, opening &c.*
刀 tau *to cut; a knife or sword.*

19 力 lee *strength; energy; exertion.*
20 勹 pau *an envelope; to wrap up.*
21 匕 pee *a spoon; bamboo stick; to eat with.*
22 匚 fang *a square box; a chest.*
23 匸 hee *same as above; a receptacle.*
24 十 shee *the numeral* ten.
25 卜 po *to prophesy; to divine.*
26 卩 tsee *a finger joint; a knot.*
27 厂 han *a cavern; a shelter.*
28 厶 tse' *crooked.*
29 又 yeu *to assist; again; and.*

OF III STROKES

30 口 koo *a mouth.*
31 囗 wei *an extended plain; something surrounding.*
32 土 too *the earth; one of the five elements.*
33 士 tze *a doctor; a learned man.*
34 夂 chee *to follow.*
35 夊 shuee *to proceed slowly.*
36 夕 sei *the evening.*
37 大 ta *great; gross; the beginning.*

38 女 neu *a woman; a virgin.*
39 子 tse' *a son or daughter; a name of great respect.*
40 宀 miou *a covering; a roof.*
41 寸 tsuoi *a measure of length or breadth; an inch.*
42 小 siau *little; slight; slender; narrow.*
43 尢 wang *deformed; crooked; a cripple.*
44 尸 shee *a dead corpse.*
45 屮 che' *a bud; grass; plants.*
46 山 shan *a hill, a mountain.*
47 巛 chuyn *a channel of running water.*
48 工 kung *work; an artificer.*
49 己 kee' *self; one'self; himself; herself.*
50 巾 kin *a napkin.*
51 干 kan *a shield; the border of a province.*
52 幺 yau *slender; the sign of the future,* shall.
53 广 yen *to protect; a shed.*
54 廴 jin *a long journey; to continue on foot a long time.*
55 廾 kung *to join hands; the number twenty.*
56 弋 ye *to dart; to throw; the head of an arrow.*
57 弓 koong *a bow.*

58 彐 kee *genus; kind; a hog's head.*
59 彡 shang *feathers; hair; fine in appearance.*
60 彳 chee *to walk; a short step.*

OF IV STROKES

61 心 sin *the heart; the mind; desire.*
62 戈 ko *a spear; a lance; dart.*
63 戶 hoo *an inner door; to guard.*
64 手 shoo *the hand; handicraft.*
65 支 chee *the branches of a tree.*
66 攴 poo *a slight stroke; to strike gently.*
67 文 wan *beautiful; fair; good; excellent.*
68 斗 tou *a certain measure; a wine vessel.*
69 斤 kin *a weight of about 22 oz.*
70 方 fang *square; right place; then.*
71 无 woo *the negative particle; to want.*
72 日 jee *the sun; the day; perfect.*
73 曰 yue' *to say; to speak; to name.*
74 月 yue' *the moon; the month.*
75 木 moo *wood; a tree; the stem of a tree.*
76 欠 kien *to owe; to sigh.*

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THE 214 ELEMENTS OR KEYS

	止	tcheo	to stop; to finish; to stand still.	96	玉	yo	a gem; a king; precious stones.	116	穴	sheu	a den or cave	135	舌	shea	the tongue.
	歹	tai	bad; evil; vicious.	97	瓜	qua	a melon; a cucumber.	117	立	hee	to erect; to build; firm.	136	舛	tchuen	to disturb; to wander; to err.
	殳	shoo	to kill by a blow; a weapon.	98	瓦	ngua	earthen vessels; tiles.		OF VI STROKES			137	舟	tcheu	a ship; a boat.
	毋	woo	the negative particle; to prohibit.	99	甘	kan	sweet; pleasant; one of the five tastes.	118	竹	tso	a reed or bamboo.	138	艮	kin	bound; limit; disobedience.
1	比	pee	to compare; to equalize.	100	生	sung	to produce; life.	119	米	mea	raw; or unspun silk.	139	色	soo	blooming; a fine colour of the skin.
2	毛	mau	hair.	101	用	yung	to employ; to use.	120	糸	mee	rice or grain cleaned of the husk.	140	艸	tsao	plants; herbs; grass.
3	氏	shee	a family name; an ancestor.	102	田	tien	a cultivated field.	121	缶	fou	earthen vessels of all kinds.	141	虍	hoo	a tiger.
4	气	kee	air; breath; living principle.	103	疋	pay	the foot; a lineal measure.	122	网	wang	a net of any kind.	142	虫	chung	an insect.
5	水	shwee	water; one of the elements.	104	疒	tsai	sickness; a sore or ulcer.	123	羊	yung	a goat; a sheep.	143	血	sheah	blood.
6	火	ho	fire; one of the elements.	105	癶	pee	skin; the hairy side of a skin; a mound.	124	羽	yeu	wings of a bird; feathers.	144	行	shing	to go; to do; to walk.
7	爪	chau	nails; claws of animals.	106	白	pee	white; clear; pure; serene:	125	老	lau	aged; a term of respect.	145	衣	ee	clothes; garments.
8	父	foo	a father; the chief of a house or family	107	皮	pe	the skin; to walk quickly.	126	而	ul or ye	an expletive; locks of hair.	146	襾	ya see	to cover; west.
9	爻	sheau	to imitate; to keep company with.	108	皿	ming	dishes; vessels used for food.	127	耒	luy	the crooked hands of a plough.		OF VII STROKES		
0	爿	tchuang	a particular kind of seat or bench.	109	目	mou	the eye.	128	耳	eul	the ear.	147	見	kien	to see; to appear.
1	片	pien	a peice of wood; a splinter.	110	矛	meu	a spear or lance.	129	聿	yoo	a pencil or brush; like.	148	角	kiou	a horn of animals
2	牙	ya	the teeth.	111	矢	tchee	straight; to point at; an arrow.	130	肉	yoo	flesh of any animal.	149	言	yen	words; to speak.
3	牛	neu	a cow.	112	石	shee	a stone; a rock.	131	臣	tchin	a minister; a public stewart.	150	谷	koo	a valley; a spring; a channel of water.
4	犬	koon	a dog.	113	示	shee	to admonish; to instruct; to advise.	132	自	tse'	self; himself; from.	151	豆	tou	leguminous plants; pulse.
	OF V STROKES			114	禸	nieu	to creep; the mark of birds feet.	133	至	tchee	the extreme point; to arrive at.	152	豕	tche	a hog; a sow.
95	玄	huen	darkish. blackish.	115	禾	quo	grain; corn in the ear.	134	臼	keu	a mortar.	153	豸	lee	a reptile.

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THE 214 ELEMENTS OR KEYS.

154	貝	poei	*a pearl; a shell; precious.*
155	赤	tchee	*red; colour of carnation.*
156	走	tsou	*to walk swiftly; to run.*
157	足	tsoo	*the foot.*
158	身	shin	*the body or person; self.*
159	車	kiou	*a wheel or carriage.*
160	辛	sin	*hot; pungent; bitter; afflicting.*
161	辰	shin	*to advance; a portion of time equal to two hours.*
162	邑	yee	*a city surrounded with walls.*
163	辵	tchoo	*walking swiftly; a hasty motion.*
164	酉	yau	*ripe; new wine.*
165	釆	pien	*to tear asunder; to seperate; to distinguish.*
166	里	lee	*a measure about one third of a mile; a village.*

OF VIII STROKES

167	金	kin	*metal; gold.*
168	長	chang	*long; remote; distant.*
169	門	mun	*the outer door.*
170	阜	foo	*a mound of earth*
171	隶	tai	*until; at; or to a certain point*
172	隹	tchuy	*birds with short tails.*
173	雨	yeu	*rain.*
174	青	ching	*azure.*
175	非	fui	*pulse; low; the negative.*
176	面	mien	*the face; the surface.*
177	革	kee	*skins with the haïr on; to change.*
178	韋	wy	*soft leather; back to back*
179	韭	kieu	*onions; leeks; pot herbs.*
180	音	yin	*sound; a tone of music.*

OF IX STROKES

181	頁	yee	*the head.*
182	風	fung	*the wind; manner; custom.*
183	飛	fooi	*to fly as a bird*
184	食	tchee	*to eat; prepared rice.*
185	首	shieu	*the head; the origin.*
186	香	shiang	*smell; fragrance*

OF X to XVII STROKES

187	馬	ma	*a horse.*
188	骨	koo	*a bone.*
189	高	kau	*high; eminent; noble.*
190	髟	piau	*long hair.*
191	鬥	tou	*to fight; a single combat.*
192	鬯	tchiang	*fragrant herbs to mix with wine*
193	鬲	lee	*a vessel used for burning incense.*
194	鬼	quoi	*a spirit; a ghost; a demon.*
195	魚	yeu	*a fish.*
196	鳥	niau	*a bird.*
197	鹵	loo	*salt or brackish water.*
198	鹿	lo	*a stag.*
199	麥	moo	*wheat; corn.*
200	麻	ma	*hemp.*
201	黃	whang	*yellow.*
202	黍	shieu	*millet.*
203	黑	shee	*black; dark.*
204	黹	tchee	*needle-work; embroidery.*
205	黽	ting	*a tripod; a vessel used in cooking.*
206	鼎	mung	*a toad or frog.*
207	鼓	koo	*a drum.*
208	鼠	shüan	*a mouse a rat.*
209	鼻	pee	*the nose.*
210	齊	shee	*even; level; to put in order.*
211	齒	tchee	*the teeth; rank order.*
212	龍	loong	*a dragon.*
213	龜	quey	*a tortoise.*
214	龠	yoo	*a pipe or musical instrument of reeds*

IN COMPOSITION

No.9 is	亻	
18 „	刂	
61 „	忄	
64 „	扌	
85 „	氵	
86 „	灬	
130 „	月	
140 „	卄	
152 „	阝	*placed on the right*
170 „	阝	*placed on the left*
163 „	辶	

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CHIVALRY.

Chivalry.

THE primitive sense of this well-known word, derived from the French *Chevalier*, signifies merely cavalry, or a body of soldiers serving on horseback; and has been used in that general acceptation by the best of our poets, ancient and modern, from Milton to Thomas Campbell.

But the present article respects the peculiar meaning given to the word in modern Europe, as applied to the order of knighthood, established in almost all her kingdoms during the middle ages, and the laws, rules, and customs, by which it was governed. Those laws and customs have long been antiquated, but their effects may still be traced in European manners; and, excepting only the change which flowed from the introduction of the Christian religion, we know no cause which has produced such general and permanent difference betwixt the ancients and moderns as that which has arisen out of the institution of chivalry. In attempting to treat this curious and important subject, rather as philosophers than as antiquaries, we cannot, however, avoid going at some length into the history and origin of the institution.

Origin of the Institution.

From the time that cavalry becomes used in war, the horseman who furnished and supported a charger arises, in all countries, into a person of superior importance to the mere foot soldier. The apparent difficulty of the art of training and managing in the field of battle an animal so spirited and active, gave the *ιπποδαμος* Εκτορ, or *Domitor equi*, in rude ages, a character of superior gallantry, while the necessary expence attending this mode of service attested his superior wealth. In various military nations, therefore, we find that horsemen are distinguished as an order in the state, and need only appeal to the *equites* of ancient Rome as a body interposed betwixt the senate and the people; or to the laws of the conquerors of New Spain, which assigned a double portion of spoil to the soldier who fought on horseback, in support of a proposition in itself very obvious. But, in the middle ages, the distinction ascribed to soldiers serving on horseback assumed a very peculiar and imposing character. They were not merely respected on account of their wealth or military skill, but were bound together by an union of a very peculiar character, which monarchs were ambitious to share with the poorest of their subjects, and governed by laws directed to enhance, into enthusiasm, the military spirit and the sense of personal honour associated with it. The aspirants to this dignity were not permitted to assume the sacred character of knighthood until after a long and severe probation, during which they practised, as acolytes, the virtues necessary to the order of chivalry. Knighthood was the goal to which the ambition of every noble youth turned, and to support its honours, which (in theory at least) could only be conferred on the gallant, the modest, and the virtuous, it was necessary he should spend a certain time in a subordinate situation, attendant upon some knight of eminence, observing the conduct of his master, as what must in future be the model of his own, and practising the virtues of humility, modesty, and temperance, until called upon to display those of an higher order.

Chivalry.

The general practice of assigning some precise period when youths should be admitted into the society of the manhood of their tribe, and considered as entitled to use the privileges of that more mature class, is common to many primitive nations. The custom, also, of marking the transition from the one state to the other, by some peculiar formality and personal ceremonial, seems so very natural, that it is quite unnecessary to multiply instances, or crowd our pages with the barbarous names of the nations by whom it has been adopted. In the general and abstract definition of Chivalry, whether as comprising a body of men whose military service was on horseback, and who were invested with peculiar honours and privileges, or with reference to the mode and period in which these distinctions and privileges were conferred, there is nothing either original or exclusively proper to our Gothic ancestors. It was in the singular tenets of Chivalry,—in the exalted, enthusiastic, and almost sanctimonious ideas connected with its duties,—in the singular balance which its institutions offered against the evils of the rude ages in which it arose, that we are to seek those peculiarities which render it so worthy of our attention.

The original institution of Chivalry has been often traced to the custom of the German tribes recorded by Tacitus. "All business," says the historian, "whether public or private, is transacted by the citizens under arms. But it is not the custom that any one shall assume the military dress or weapons without the approbation of the state. For this purpose, one of the chief leaders, or the father or nearest relation of the youthful candidate, introduces him into the assembly, and confers on him publicly a buckler and javelin. These arms form the dress proper to manhood, and are the first honour conferred on youth. Before he receives them, the young man is but a member of his own family, but after this ceremony he becomes a part of the state itself." (*Germania* Taciti.) The records of the northern nations, though we cannot rely upon their authenticity with the same unlimited confidence, because we conceive most of the legends relating to them have been written at a much later period than the times in which the scene is laid, may be referred to in confirmation of the Roman historians. The Scandinavian legends and *Sagas* are full of the deeds of those warriors whom they termed heroes or champions, and who appear to have been formed into an order somewhat resembling that of Chivalry, and certainly followed the principal and most characteristic employment of its profession; wandering from court to court, and from shore to shore, bound on high adventure, and seeking with equal readiness their fortunes in love and in war. It would not be difficult to deduce from this very early period some of those peculiar habits and customs, which, brought by the Gothic conquerors into the provinces of the divided empire of Rome, subsisted and became

ingrafted upon the institutions of Chivalry. Tacitus, for example, informs us, that among the Germans, and especially among the Catti, every youthful champion permitted his beard and hair to grow, and did not shave them until he had performed some signal feat of arms. In the like manner, as the general reader may have learned from that irrefragable authority, Don Quixote de la Mancha, a knight who received his order, was obliged to wear white armour and a shield without a device, until, by some daring and distinguished achievement, he had acquired title to an honourable badge of distinction. If this correspondence of customs shall be thought too far fetched and too general, the next, which we also derive from Tacitus, is too close to be disputed. The German warriors who piqued themselves upon this bravery, used, at the commencement of a war, to assume an iron ring, after the fashion of a shackle, upon their arm, which they did not remove until they had slain an enemy. The reader may be pleased to peruse the following instance of a similar custom from the French romance of *Jehan de Saintré*, written in the year 1459, and supposed to be founded, in a great measure, upon real incidents.* The hero, with nine companions at arms, four of whom were knights and five squires, vowed to carry a helmet of a particular shape, that of the knights having a visor of gold, and that of the squires a visor of silver. Thus armed, they were to travel from court to court for the space of three years, defying the like number of knights and squires, wherever they came, to support the beauty of their mistresses with sword and lance. The emblems of their enterprise were chained to their left shoulders, nor could they be delivered of them until their vow was honourably accomplished. Their release took place at the court of the Emperor of Germany, after a solemn tournament, and was celebrated with much triumph. In like manner, in the same romance, a Polish knight, called the Seigneur de Loiselench, is described as appearing at the court of Paris wearing a light gold chain attached to his wrist and ancle in token of a vow, which emblem of bondage he had sworn to wear for five years, until he should find some knight or squire without reproach, by encountering with whom he might be *delivered* (such was the phrase) of his vow and enterprise. Lord Herbert of Cherbury mentions, in his memoirs, that when he was made Knight of the Bath, a tassel of silken cordage was attached to the mantle of the order, which, doubtless, had originally the same signification as the shackle worn by the German champion. The rule was, however, so far relaxed, that the knot was unloosed so soon as a lady of rank gaged her word that the new Knight of the Bath would do honour to the order; and Lord Herbert, whose punctilious temper set great store by the niceties of chivalrous ceremony, fails not to record, with becoming gratitude, the name of the honourable dame who became his security on this important occasion.

Other instances might be pointed out, in which the ancient customs of the Gothic tribes may be traced in the history of chivalry; but the above are enough to prove that the seeds of that singular institution existed in the German forests, though they did not come to maturity until the destruction of the Roman empire, and the establishment of the modern states of Europe upon its ruins.

Having thus given a general view of the origin of chivalry, we will, I. briefly notice the causes from which it drew its peculiar characters, and the circumstances in which it differs so widely from the martial character as it existed, either among the ancient Greeks and Romans, or in other countries and nations. II. We will attempt a general abstract of its institutions. III. The rise and progress of chivalry,—its effects upon the political state of Europe,—and its decay and extinction, will close the article.

I. Agreeably to this general division, the general nature and spirit of the institution of chivalry falls first under our consideration.

Peculiar Nature and Spirit of this Institution.

In every age and country valour is held in esteem, and the more rude the period and the place, the greater respect is paid to boldness of enterprise and success in battle. But it was peculiar to the institution of Chivalry, to blend military valour with the strongest passions which actuate the human mind, the feelings of devotion and those of love. The Greeks and Romans fought for liberty or for conquest, and the knights of the middle ages for God and for their ladies. Loyalty to their sovereigns was a duty also incumbent upon these warriors, but although a powerful motive, and by which they often appear to have been strongly actuated, it entered less warmly into the composition of the chivalrous principle than the two preceding causes. Of patriotism, considered as a distinct predilection to the interests of one kingdom, we find comparatively few traces in the institutions of knighthood. But the love of personal freedom, and the obligation to maintain and defend it in the persons of others as in their own, was a duty particularly incumbent on those who attained the honour of chivalry. Generosity, gallantry, and an unblemished reputation, were no less necessary ingredients in the character of a perfect knight. He was not called upon simply to practise these virtues when opportunity offered, but to be sedulous and unwearied in searching for the means of exercising them, and to push them without hesitatation to the brink of extravagance, or even beyond it. Founded on principles so pure, the order of chivalry could not, in the abstract at least, but occa-

* We may here observe, once for all, that we have no hesitation in quoting the romances of chivalry as good evidence of the laws and customs of knighthood. The authors, like the painters of the period, invented nothing, but copying the manners of the age in which they lived, transferred them without doubt or scruple to the period and personages of whom they treated. But the romance of *Jehan de Saintré* is still more authentic evidence, as it is supposed to contain no small measure of fact, though disguised and distorted. Probably the achievement of the Polish knights may have been a real incident.

sion a pleasing, though a romantic developement of the energies of human nature. But as, in actual practice, every institution becomes deteriorated and degraded, we have too much occasion to remark, that the devotion of the knights often degenerated into superstition,—their love into licentiousness,—their spirit of loyalty or of freedom into tyranny and turmoil,—their generosity and gallantry into hair-brained madness and absurdity.

We have mentioned devotion as a principal feature in the character of chivalry. At what remote period the forms of chivalry were first blended with those of the Christian religion, would be a long and difficult inquiry. The religion which breathes nothing but love to our neighbour and forgiveness of injuries, was not, in its primitive purity, easily transferable into the warlike and military institutions of the Goths, the Franks, and the Saxons. At its first infusion, it appeared to soften the character of the people among whom it was introduced so much, as to render them less warlike than their heathen neighbours. Thus the pagan Danes ravaged England when inhabited by the Christian Saxons,—the heathen Normans conquered Neustria from the Franks,—the converted Goths were subdued by the sword of the heathen Huns,—the Visigoths of Spain fell before the Saracens. But the tide soon turned. As the necessity of military talent and courage became evident, the Christian religion was used by its ministers (justly and wisely so far as respected self-defence) as an additional spur to the temper of the valiant. Those books of the Old Testament which Ulphilas declined to translate, because they afforded too much fuel for the military zeal of the ancient Goths, were now commented upon to animate the sinking courage of their descendants. Victory and glory on earth, and a happy immortality after death, were promised to those champions who should distinguish themselves in battle against the infidels. And who shall blame the preachers who held such language, when it is remembered that the Saracens had at one time nearly possessed themselves of Aquitaine, and that but for the successful valour of Charles Martel, Pepin, and Charlemagne, the crescent might have dispossessed the cross of the fairest portion of Europe. The fervent sentiments of devotion which direct men's eyes toward heaven, were then justly invoked to unite with those which are most valuable on earth,—the love of our country and its liberties.

But the Romish clergy, who have in all ages possessed the wisdom of serpents, if they sometimes have fallen short of the simplicity of doves, saw the advantage of converting this temporary zeal, which animated the warriors of their creed against the invading infidels, into a permanent union of principles, which should blend the ceremonies of religious worship with the military establishment of the ancient Goths and Germans. The admission of the noble youth to the practice of arms was no longer a mere military ceremony, where the sword or javelin was delivered to him in presence of the prince or elders of his tribe; it became a religious rite, sanctified by the forms of the church which he was in future to defend. The novice had to watch his arms in a church or chapel, or at least on hallowed ground, the night before he had received the honour of knighthood. He was made to assume a white dress, in imitation of the Neophytes of the church. Fast and confession were added to vigils, and the purification of the bath was imposed on the military acolyte, in imitation of the initiatory rite of Christianity; and he was attended by godfathers, who became security for his performing his military vows, as sponsors had formerly appeared for him at baptism. In all points of ceremonial, the investiture of chivalry was brought to resemble, as nearly as possible, the administration of the sacraments of the church. The ceremony itself was performed, where circumstances would admit, in a church or cathedral, and the weapons with which the young warrior was invested were previously blessed by the priest. The oath of chivalry bound the knight to defend the rights of the holy church, to respect religious persons and institutions, and to obey the precepts of the gospel. Nay, more, so intimate was the union betwixt chivalry and religion supposed to be, that the several gradations of the former were seriously considered as parallel to those of the church, and the knight was supposed to resemble the bishop in rank, duties, and privileges. At what period this complete infusion of religious ceremonial into an order purely military first commenced, and when it became complete and perfect, would be a curious but a difficult subject of investigation. Down to the reign of Charlemagne, and somewhat lower, the investiture was of a nature purely civil; but long before the time of the crusades, it had assumed the religious character we have described.

The effect which this union of religious and military zeal was like to produce in every other case save that of defensive war, could not but be unfavourable to the purity of the former. The knight, whose profession was war, being solemnly enlisted in the service of the gospel of peace, regarded infidels and heretics of every description as the enemies whom, as God's own soldier, he was called upon to attack and slay wherever he could meet with them, without demanding or waiting for any other cause of quarrel than the difference of religious faith. The duties of morality were indeed formally imposed on him by the oath of his order, as well as that of defending the church, and extirpating heresy and misbelief. But, in all ages, it has been usual for men to compound with their consciences for breaches of the moral code of religion, by a double proportion of zeal for its abstract doctrines. In the middle ages, this course might be pursued on system; for the church allowed an exploit done on the infidels as a merit which might obliterate the guilt of the most atrocious crimes.

The genius alike of the age and of the order tended to render the zeal of the professors of chivalry fierce, burning, and intolerant. If an infidel, says a great authority, impugn the doctrines of the Christian faith before a churchman, he should reply to him by argument; but a knight should render no other reason to the infidel than six inches of his falchion thrust into his accursed bowels. Even courtesy, and the respect due to ladies of high degree, gave way

when they chanced to be infidels. The renowned Sir Bevis of Hamptoun, being invited by the fair princess Josiane to come to her bower, replies to the paymims who brought the message,

> " I will ne gou one foot on ground
> For to speke with an heathen hound;
> Unchristen houndes, I rede ye flee,
> Or I your hearte's bloode will see."

This intemperate zeal for religion the knights were expected to maintain at every risk, however imminent. Like the early Christians, they were prohibited from acquiescing, even by silence, in the rites of idolatry, although death should be the consequence of their interrupting them. In the fine romance of *Huon of Bourdeaux*, that champion is represented as having failed in duty to God and his faith, because he had professed himself a Saracen for the temporary purpose of obtaining entrance into the palace of the Amial Gaudifer. " And when Sir Huon passed the third gate, he remembered him of the lie he had spoken to obtain entrance into the first. Alas! said the knight, what but destruction can betide one who has so foully falsified and denied his faith towards him who has done so much for me!" His mode of repentance was truly chivalrous. When he came to the gate of the last interior inclosure of the castle, he said to the warder, " Pagan, accursed be thou of God, open the gate." When he entered the hall where the pagan monarch was seated in full state, he struck off, without ceremony, the head of the pagan lord who sat next in rank to him, exclaiming at the same time with a loud voice, " God, thou hast given me grace well to commence my emprize; may our Redeemer grant me to bring it to an honourable conclusion." Many such passages might be quoted to show the nature of the zeal which was supposed to actuate a Christian knight. But it is needless to ransack works of fiction for this purpose. The real history of the crusades, founded on the spirit of chivalry, and on the restless and intolerant zeal which was blended by the churchmen with this military establishment, are an authentic and fatal proof of the same facts. The hair-brained and adventurous character of these enterprises, not less than the promised pardons, indulgences, and remissions of the church, rendered them dear to the warriors of the middle ages; the idea of reestablishing the Christian religion in the Holy Land, and wresting the tomb of Christ from the infidels, made kings, princes, and nobles, blind to its hazards; and they rushed, army after army, to Palestine, in the true spirit of chivalry, whose faithful professors felt themselves the rather called upon to undertake an adventure from the peculiar dangers which surrounded it, and the numbers who had fallen in previous attempts.

It was after the conquest of the Holy Land that the union between temporal and spiritual chivalry (for such was the term sometimes given to monastic institutions) became perfect, by the institution of the two celebrated military orders of monks, the Knights Templars and Knights of St John of Jerusalem, who, renouncing (at least in terms) the pomp, power, and pleasures of the world, and taking upon themselves the monastic vows of celibacy, purity, and obedience, did not cease to remain soldiers, and directed their whole energy against the Saracens. The history of these orders will be found in its proper place in this work; but their existence is here noticed as illustrating our general proposition concerning the union of devotion and chivalry. A few general remarks will close this part of the subject.

The obvious danger of teaching a military body to consider themselves as missionaries of religion, and bound to spread its doctrines, is, that they are sure to employ in its service their swords and lances. The end is held to sanctify the means, and the slaughter of thousands of infidels is regarded as an indifferent, or rather as a meritorious action, providing it may occasion the conversion of the remnant, or the peopling their land with professors of a purer faith. The wars of Charlemagne in Saxony, the massacres of the Albigenses in the south of France, the long-continued wars of Palestine, all served to illustrate the dangers resulting from the doctrine which inculcated religion not as a check upon the horrors and crimes of war, but as itself its most proper and legitimate cause. The evil may be said to have survived the decay of Chivalry, to have extended itself to the new world, and to have occasioned those horrors with which it was devastated for ages after its first discovery. The Spanish conquerors of South America were not, indeed, knights-errant, but the nature of their enterprises, as well as the mode in which they were conducted, partook deeply of the spirit of Chivalry. In no country of Europe had this spirit sunk so deeply and spread so wide as in Spain. The extravagant positions respecting the point of honour, and the romantic summons which Chivalry proclaimed to deeds of danger and glory, suited the ardent and somewhat oriental character of the Spaniards, a people more remarkable for force of imagination, and depth of feeling, than for wit or understanding. Chivalry, in Spain, was embittered by a double proportion of intolerant bigotry, owing to their constant and inveterate wars with the Moorish invaders. The strain of sentiment, therefore, which Chivalry inspired, continued for a long time to mark the manners of Spain after the decay of its positive institutions, as the beams of the sun tinge its horizon after the setting of his orb. The warriors whom she sent to the new world sought and found marvels which resembled those of romance; they achieved deeds of valour against such odds of numbers as are only recorded in the annals of knight-errantry; and alas! they followed their prototypes in that indifference for human life which is the usual companion of intolerant zeal. Avarice, indeed, brought her more sordid shades to complete the gloomy picture; and avarice was unknown to the institutions of Chivalry. The intolerant zeal, however, which overthrew the altars of the Indians by violence, instead of assailing their errors by reason, and which imputed to them as crimes their ignorance of a religion which had never been preached to them, and their rejection of speculative doctrines of faith propounded by persons whose practice was so ill calculated to recommend them—all these may be traced to the

spirit of Chivalry, and the military devotion of its professors.

The religion of the knights, like that of the times, was debased by superstition. Each champion had his favourite saint, to whom he addressed himself upon special occasions of danger, and to whom, after the influence of his lady's eyes, he was wont to ascribe the honour of his conquests. St Michael, the leader of banded Seraphim, and the personal antagonist of Satan,—St George, St James, and St Martin, all of whom popular faith had invested with the honours of Chivalry,—were frequently selected as the appropriate champions of the militant adventurers yet on earth. The knights used their names adjected to their own as their insignia, watch-word, or signal for battle. Edward III. fighting valiantly in a night-skirmish before the gates of Calais, was heard to accompany each blow he struck with the invocation of his tutelar saints, Ha! Saint Edward! ha! St George! But the Virgin Mary, to whom their superstition ascribed the qualities of youth, beauty, and sweetness, which they prized in their terrestrial mistresses, was an especial object of the devotion of the followers of Chivalry, as of all other good Catholics. Tournaments were undertaken, and feats of arms performed in her honour, as in that of an earthly mistress, and the veneration with which she was regarded seems occasionally to have partaken of the character of romantic affection. She was often held to return this love by singular marks of her favour and protection. During an expedition of the Christians to the coast of Africa, Froissart informs us that a large black dog was frequently seen in their camp, which barked furiously whenever the infidels approached it by night, and rendered such service to the Christian adventurers by its vigilance, that with one consent they named it "The Dog of our Lady."

But although, as is incidental to human institutions, the mixture of devotion in the military character of the knight degenerated into brutal intolerance and superstition, in its practical effects, nothing could be more beautiful and praiseworthy than the theory on which it was grounded. That the soldier drawing the sword in defence of his country and its liberties, or of the oppressed innocence of damsels, widows, and orphans, or in support of religious rights, for which those to whom they belonged were disqualified by their profession to combat in person, —that he should blend with all the feelings which these offices inspired, a deep sense of devotion, exalting him above the advantage and even the fame which he himself might derive from victory, and giving dignity to defeat itself, as a lesson of divine chastisement and humiliation; that the knight on whose valour his countrymen were to rely in danger should set them an example in observing the duties and precepts of religion, are circumstances so well qualified to soften, to dignify, and to grace the profession of arms, that we cannot but regret their tendency to degenerate into a ferocious propensity to bigotry, persecution, and intolerance. Such, however, is the tendency of all human institutions, which, however fairly framed in theory, are in practice corrupted by our evil passions, until the results which flow from them become the very reverse of what was to have been expected and desired.

The next ingredient in the spirit of Chivalry, second in force only to the religious zeal of its professors, and frequently predominating over it, was a devotion to the female sex, and particularly to her whom each knight selected as the chief object of his affection, of a nature so extravagant and unbounded as to approach to a sort of idolatry.

The original source of this sentiment is to be found, like that of Chivalry itself, in the customs and habits of the northern tribes, who possessed, even in their rudest state, so many honourable and manly distinctions, over all the other nations in the same stage of society. The chaste and temperate habits of these youth, and the opinion that it was dishonourable to hold sexual intercourse until the twentieth year was attained, was in the highest degree favourable not only to the morals and health of the ancient Germans, but must have contributed greatly to place the females in that dignified and respectable rank which they held in society. Nothing tends so much to blunt the feelings, to harden the heart, and to destroy the imagination, as the worship of the Vaga Venus in early youth. Wherever women have been considered as the early, willing, and accommodating slaves of the voluptuousness of the other sex, their character has become degraded, and they have sunk into domestic drudges and bondswomen among the poor,—the slaves of a haram among the more wealthy. On the other hand, the men, easily and early sated with indulgences, which soon lose their poignancy when the senses only are interested, become first indifferent, then harsh and brutal to the unfortunate slaves of their pleasures. The sated lover,—and perhaps it is the most brutal part of humanity,—is soon converted into the capricious tyrant, like the successful seducer of the modern poet.

> "Hard! with their fears and terrors to behold
> The cause of all, the faithless lover cold,
> Impatient grown at every wish denied,
> And barely civil, soothed and gratified."
>
> Crabbe's *Borough*, p. 213.

Habitual indulgence seeks change of objects to relieve satiety. Hence polygamy, and all its brutalizing consequences, which were happily unknown to our Gothic ancestors. The virtuous and manly restraints imposed on their youth were highly calculated to exalt the character of both sexes, and especially to raise the females in their own eyes and those of their lovers. They were led to regard themselves, not as the passive slaves of pleasure, but as the objects of a prolonged and respectful affection, which could only be finally gratified when their lovers had attained the age of mature reason, and was capable to govern and to defend the family which should arise around them. With the young man imagination and sentiment combined to heighten his ideas of a pleasure which nature instructed him to seek, and which the wise laws of his country prevented him from prematurely aspiring to share. To a youth so situated, the maiden on whom he placed his affections became an object of awe as well as of affection; the passion which he indulged for her was of a nature as

timid and pure as engrossing and powerful; the minds of the parties became united before the joining of their hands, and a moral union preceded the mere intercourse of the sexes.

The marriages formed under these happy auspices were, in general, happy and affectionate. Adultery was unfrequent, and punished with the utmost rigour; nor could she who had undergone the penalty of such a crime find a second husband, however distinguished by beauty, birth, or wealth. (Taciti *Germania.*) The awe and devotion with which the lover had regarded his destined bride during the years in which the German youth were enjoined celebacy, became regard and affection in the husband towards the sharer of his labours and the mistress of his household. The matron maintained that rank in society which love had assigned to the maiden. No one then, says the Roman historian, dared to ridicule the sacred union of marriage, or to term an infringement of its laws a compliance with the manners of the age. The German wife, once married, seldom endeavoured to form a second union, but continued, in honoured widowhood, to direct and manage the family of her deceased husband. This habitual subjection of sensuality to sentiment, these plain, simple, virtuous, and temperate manners of the German females, placed the females in that high rank of society which the sex occupies when its conduct is estimable, and from which it as certainly declines in ages or climates prone to luxurious indulgence. The superintendence of the domestic affairs was assigned to the German women, a duty in which the men seldom interfered, unless when rendered by age or wounds incapable of warfare. They were capable of exercising the supreme authority in their tribe, and of holding the honours of the priesthood. But the influence of the women in a German tribe, as well as their duties in war, will be best understood from the words of Tacitus. "It is the principal incitement to the courage of the Germans, that in battle their separate troops or columns are not arranged promiscuously as chance directs, but consist each of an united family or clan with its relatives. Their dearest pledges are placed in the vicinity, whence may be heard the cries of their females, the wailings of their infants, whom each accounts the most sacred witnesses and the dearest eulogists of his valour. The wounded repair to their mothers and spouses, who hesitate not to number their wounds, and to suck the blood that flows from them. The females carry refreshment to those engaged in the contest, and encourage them by their exhortations. It is related, that armies, when disordered and about to give way, have renewed the contest at the instance of the women; moved by the earnestness of their entreaties, their exposed bosoms, and the danger of approaching captivity;—a doom which they dread more on account of their females than even on their own;—insomuch, that these German states are most effectually bound to obedience, among the number of whose hostages there are noble damsels as well as men. They deem, indeed, that there resides in the female sex something sacred and capable of presaging the future; nor do they scorn their advice or neglect their responses. In the time of Vespasian we have seen Velleda long hold the rank of a deity in most of the German states; and, in former times, they venerated Aurinia and other females; not, however, from mere flattery, nor yet in the character of actual goddesses." The tales and *Sagas* of the north, in which females often act the most distinguished part, might also be quoted as proofs of the rank which they held in society. We find them separating the most desperate frays by their presence, their commands, or their mantles, which they threw over the levelled weapons of the combatants. Nor were their rights less extensive than their authority. In the *Eyrbiggia Saga* we are informed, that Thordisa, the mother of the celebrated Pontiff Snorro, and wife of Biarko of Stelgafels, received a blow from her husband. The provocation was strong, for the matron had, in her husband's house and at his table, attempted to stab his guest Eyalf Graie, on account of his having slain one of her relations. Yet so little did this provocation justify the offence, that, in the presence of the comitia, or public assembly of the tribe, Thordisa invoked witnesses to bear testimony that she divorced her husband on account of his having raised his hand against her person. And such were the rights of a northern *mater-familias*, that the divorce and a division of goods immediately took place between the husband and wife, although the violence of which Thordisa complained was occasioned by her own attempt to murder a guest.

We have traced the ideas of the Gothic tribes on this important point the more at length, because they show, that the character of veneration, sanctity, and inviolability attached to the female character, together with the important part assigned to them in society, were brought with them from their native forests, and had existence long before the chivalrous institutions in which they made so remarkable a feature. They easily became amalgamated in a system so well fitted to adopt whatever was romantic and enthusiastic in manners or sentiment. Amid the various duties of knighthood, that of protecting the female sex, respecting their persons, and redressing their wrongs, becoming the champion of their cause, and the chastiser of those by whom they were injured, was presented as one of the principal objects of the institution. Their oath bound the new-made knights to defend the cause of all women without exception; and the most pressing way of conjuring them to grant a boon was to implore it in the name of God and the ladies. The cause of a distressed lady was, in many instances, preferable to that even of the country to which the knight belonged. Thus, the Captal de Buche, though an English subject, did not hesitate to unite his troops with those of the Compte de Foix, to relieve the ladies in a town where they were besieged and threatened with violence by the insurgent peasantry. The looks, the words, the sign of a lady were accounted to make knights at time of need perform double their usual deeds of strength and valour. At tournaments and in combats, the voices of the ladies were heard like those of the German females in former battles, calling on the knights to remember their fame, and exert themselves to the uttermost. "Think gentle knights," was their cry, "upon the wool of your breasts, the nerve of your arms, the

love you cherish in your hearts, and do valiantly, for ladies behold you." The corresponding shouts of the combatants were, "Love of ladies! Death of warriors! On, valiant knights, for you fight under fair eyes."

Where the honour or love of a lady was at stake, the fairest prize was held out to the victorious knight, and champions from every quarter were sure to hasten to combat in a cause so popular. Chaucer, when he describes the assembly of the knights who came with Arcita and Palemon to fight for the love of the fair Emilie, describes the manners of his age in the following lines.

> "For every knight that loved chivalry,
> And would his thankes have a passant name,
> Hath pray'd that he might ben of that game,
> And well was him that thereto chusen was
> For if there fell to-morrow such a case,
> Ye knowen well that every lusty knight
> That loveth par amour, and hath his might,
> Were it in Engellonde, or elleswhere,
> They wold hir thankes willen to be there.
> To fight for a lady! Ah! Benedicite
> It were a lusty sight for to see."

It is needless to multiply quotations on a subject so trite and well known. The defence of the female sex in general, the regard due to their honour, the subservience paid to their commands, the reverend awe and courtesy, which, in their presence, forbear all unseemly words and actions, were so blended with the institution of chivalry, as to form its very essence.

But it was not enough that the "very perfect, gentle knight," should reverence the fair sex in general. It was essential to his character that he should select, as his proper choice, "a lady and a love," to be the polar star of his thoughts, the mistress of his affections, and the directress of his actions. In her service, he was to observe the duties of loyalty, faith, secrecy, and reverence. Without such an empress of his heart, a knight, in the phrase of the times, was a ship without a rudder, a horse without a bridle, a sword without a hilt; a being, in short, devoid of that ruling guidance and intelligence, which ought to inspire his bravery, and direct his actions.

The Dame des Belles Cousines, having cast her eyes upon the little Jean de Saintré, then a page of honour at court, demanded of him the name of his mistress and his love, on whom his affections were fixed. The poor boy, thus pressed, replied, that the first object of his love was the lady his mother, and the next his sister Jacqueline. "Jouvencel," replied the inquisitive lady, who had her own reasons for not being contented with this simple answer, "we do not now talk of the affection due to your mother and sister; I desire to know the name of the lady whom you love *par amours*." "In faith, madam," said the poor page, to whom the mysteries of chivalry, as well as of love, were yet unknown, "I love no one *par amours*."—"Ah, false gentleman, and traitor to the laws of chivalry," returned the lady, "dare you say that you love no lady? well may we perceive your falsehood and craven spirit by such an avowal. Whence were derived the great valour and the high achievements of Lancelot of Gawain, of Tristrem, of Giron the Courteous, and of other heroes of the Round Table,—whence those of Panthus, and of so many other valiant knights and squires of this realm, whose names I could enumerate had I time,—whence the exaltation of many whom I myself have known to arise to high dignity and renown, except from their animating desire to maintain themselves in the grace and favour of their ladies, without which mainspring to exertion and valour, they must have remained unknown and insignificant. And do you, coward page, now dare to aver, that you have no lady, and desire to have none? Hence false heart that thou art." To avoid these bitter reproaches, the simple page named as his lady and love *par amour* Matheline de Coucy, a child of ten years old. The answer of the Dame des Belles Cousines, after she had indulged in the mirth which his answer prompted, instructed him how to place his affections more advantageously; and as the former part of the quotation may show the reader how essential it was to the profession of chivalry, that every one of its professors should elect a lady of his affections, that which follows explains the principles on which his choice should be regulated. "Matheline," said the lady, "is indeed a pretty girl, and of high rank, and better lineage than appertains to you. But what good, what profit, what honour, what advantage, what comfort, what aid, what council for advancing you in the ranks of chivalry, can you derive from such a choice? Sir, you ought to choose a lady of high and noble blood, who has the talent and means to counsel and aid you at your need, and her you ought to serve so truly, and love so loyally, that she must be compelled to acknowledge the true and honourable affection which you bear to her. For believe there is no lady, however cruel and haughty, but through length of faithful service will be brought to acknowledge and reward loyal affection with some portion of pity, compassion, or mercy. In this manner, you will attain the praise of a worthy knight, and till you follow such a course, I would not give an apple for you or your achievements." The lady then proceeds to lecture the acolyte of Chivalry at considerable length on the seven mortal sins, and the way in which the true amorous knight may eschew commission of them. Still, however, the saving grace inculcated in her sermon was fidelity and secrecy in the service of the mistress whom he should love *par amours*. She proves, by the aid of quotations from the Scripture, the fathers of the church, and the ancient philosophers, that the true and faithful lover can never fall into the crimes of Pride, Anger, Envy, Sloth, or Gluttony. From each of these his true faith is held to warrant and defend him. Nay, so pure was the nature of the flame which she recommended, that she maintained it to be inconsistent even with the seventh sin of Chambering and Wantonness, to which it might seem too nearly allied. The least dishonest thought or action was, according to her doctrine, sufficient to forfeit the chivalrous lover the favour of his lady. It seems, however, that the greater part of her charge concerning incontinence is levelled against such as haunted the receptacles of open vice; and that she reserved an exception (of

which, in the course of the history, she made liberal use) in favour of the intercourse which, in all love, honour, and secrecy, might take place when the favoured and faithful knight had obtained, by long service, the boon of amorous mercy from the lady whom he loved *par amours*. The last encouragement which the Dames des Belles Cousines held out to Saintré, in order to excite his ambition, and induce him to fix his passion upon a lady of elevated birth, rank, and sentiment, is also worthy of being quoted, since it shows that it was the prerogative of Chivalry to abrogate the distinctions of rank, and elevate the hopes of the knight, whose sole patrimony was his arms and valour, to the high-born and princely dame, before whom he carved as a sewer.

"How is it possible for me," replied poor Saintré, after having heard out the unmercifully long lecture of the Dame des Belles Cousines, "to find a lady, such as you describe, who will accept of my service, and requite the affection of such a one as I am?"—"And why should you not find her?" answered the lady preceptress. "Are you not gently born? Are you not a fair and proper youth? Have you not eyes to look on her—ears to hear her—a tongue to plead your cause to her—hands to serve her—feet to move at her bidding—body and heart to accomplish loyally her commands? And, having all these, can you doubt to adventure yourself in the service of any lady whatsoever?"

In these extracts is painted the actual manners of the age of chivalry. The necessity of the perfect knight having a mistress, whom he loved *par amours*, the duty of dedicating his time to obey her commands, however capricious, and his strength to execute extravagant feats of valour, which might redound to her praise,—for all that was done for her sake, and under her auspices, was counted her merit, as the victories of their generals were ascribed to the Roman Emperors,—was not a whit less necessary to complete the character of a good knight than the Dame des Belles Cousines represented it.

It was the especial pride of each distinguished champion, to maintain, against all others, the superior worth, beauty, and accomplishments of his lady; to bear her picture from court to court, and support, with lance and sword, her superiority to all other dames, abroad or at home. To break a spear for the love of their ladies, was a challenge courteously given, and gently accepted, among all true followers of chivalry; and history and romance are alike filled with the tilts and tournaments which took place upon this argument, which was ever ready and ever acceptable. Indeed, whatever the subject of the tournament had been, the lists were never closed until a solemn course had been made in honour of the ladies.

There were knights yet more adventurous, who sought to distinguish themselves by singular and uncommon feats of arms in honour of their mistresses, and such was usually the cause of the whimsical and extravagant vows of arms which we have subsequently to notice. To combat against extravagant odds, to fight amid the press of armed knights without some essential part of their armour, to do some deed of audacious valour in face of friend and foe, were the services by which the knights strove to recommend themselves, or which their mistresses (very justly so called) imposed on them as proofs of their affection.

On such occasions, the favoured knight, as he wore the colours and badge of the lady of his affections, usually exerted his ingenuity in inventing some device or cognisance which might express their affection, either openly, as boasting of it in the eye of the world, or in such mysterious mode of indication as should only be understood by the beloved person, if circumstances did not permit an avowal of his passion. Among the earliest instances of the use of the English language at the court of the Norman monarchs, is the distich painted in the shield of Edward III. under the figure of a white swan, being the device which that warlike monarch wore at a tourney, at Windsor.

"Ha! ha! the white swan,
By God his soul, I am thy man."

The choice of these devices was a very serious matter; and the usurpation of such as any knight had previously used and adopted, was often the foundation of a regular quarrel, of which many instances occur in Froissart and other writers.

The ladies, bound as they were in honour to requite the passion of their knights, were wont, on such occasions, to dignify them by the present of a scarf, ribbon, or glove, which was to be worn in the press of battle and tournament. These marks of favour they displayed on their helmets, and they were accounted the best incentives to deeds of valour. The custom appears to have prevailed in France to a late period, though polluted with the grossness so often mixed with the affected refinement and gallantry of that nation. In the attack made by the Duke of Buckingham upon the Isle of Rhé, favours were found on the persons of many of the French soldiers who fell at the skirmish on the landing, but for the manner in which they were disposed, we are compelled to refer to Howel and Wilson.

Sometimes the ladies, in conferring these tokens of their favour, clogged them with the most extravagant and severe conditions. But the lover had this advantage in such cases, that if he ventured to encounter the hazard imposed, and chanced to survive it, he had, according to the fashion of the age, the right of exacting, from the lady, favours corresponding in importance. The annals of Chivalry abound with stories of cruel and cold fair ones who subjected their lovers to extremes of danger, in hopes that they might get rid of their addresses, but were, upon their unexpected success, caught in their own snare, and, as ladies who would not have their name made the theme of reproach by every minstrel, compelled to recompense the deeds which their champion had achieved in their name. There are instances in which the lover used his right of reprisals with some rigour, as in the well known *fabliau* of the three knights and the shift; in which

 a lady proposes to her three lovers, successively, the task of entering, unarmed, into the melée of a tournament arrayed only in one of her shifts. The perilous proposal is declined by two of the knights and accepted by the third, who thrusts himself, in the unprotected state required, into all the hazards of the tournament, sustains many wounds, and carries off the prize of the day. On the next day the husband of the lady (for she was married) was to give a superb banquet to the knights and nobles who had attended the tourney. The wounded victor sends the shift back to its owner, with his request, that she would wear it over her rich dress on this solemn occasion, soiled and torn as it was, and stained all over with the blood of its late wearer. The lady did not hesitate to comply, declaring, that she regarded this shift, stained with the blood of her "fair friend as more precious than if it were of the most costly materials." Jaques de Basin, the minstrel, who relates this curious tale, is at a loss to say whether the palm of true love should be given to the knight or to the lady on this remarkable occasion. The husband, he assures us, had the good sense to seem to perceive nothing uncommon in the singular vestment with which his lady was attired, and the rest of the good company highly admired her courageous requital of the knight's gallantry.

Sometimes the patience of the lover was worn out by the cold-hearted vanity which thrust him on such perilous enterprises. At the court of one of the German Emperors, while some ladies and gallants of the court were looking into a den where two lions were confined, one of them purposely let her glove fall within the palisade which inclosed the animals, and commanded her lover, as a true knight, to fetch it out to her. He did not hesitate to obey; jumped over the inclosure; threw his mantle towards the animals as they sprung at him; snatched up the glove, and regained the outside of the palisade. But when in safety, he proclaimed aloud, that what he had achieved was done for the sake of his own reputation, and not for that of a false lady, who could for her sport and cold-blooded vanity face a brave man on a duel so desperate. And with the applause of all that were present, he renounced her love for ever.

This, however, was an uncommon circumstance. In general, the lady was supposed to have her lover's character as much at heart as her own, and to mean, by pushing him upon enterprizes of hazard, only to give him an opportunity of meriting her good graces, which she could not with honour confer upon one undistinguished by deeds of chivalry. An affecting instance is given by Godscroft.

At the time when the Scotch were struggling to recover from the usurpation of Edward I., the castle of Douglas was repeatedly garrisoned by the English, and these garrisons were as frequently surprised, and cut to pieces by the good Lord James of Douglas, who, lying in the mountainous wilds of Cairntable, and favoured by the intelligence which he maintained among his vassals, took opportunity of the slightest relaxation of vigilance to surprise the fortress. At length, a fair dame of England announced to the numerous suitors who sought her hand, that she would confer it on the man who should keep the perilous castle of Douglas (so it was called) for a year and a day. The knight who undertook this dangerous task at her request discharged his duty like a careful soldier for several months, and the lady relenting at the prospect of his continued absence, sent a letter to recall him, declaring she held his probation as accomplished. In the meantime, however, he had received a defiance from Douglas, threatening him, that, let him use his utmost vigilance, he would recover from him his father's castle before Palm-Sunday. The English knight deemed that he could not in honour leave the castle till this day was past; and on the very eve of Palm-Sunday was surprised and slain with the lady's letter in his pocket, the perusal whereof greatly grieved the good Lord James of Douglas.

We are left much to our own conjectures on the appearance and manners of these haughty beauties, who were wooed with sword and lance, whose favours were bought at the expence of such dear and desperate perils, and who were worshipped, like heathen deities, with human sacrifices. The character of the ladies of the ages of chivalry was probably determined by that of the men, to whom it sometimes approached. Most of these heroines were educated to understand the treatment of wounds, not only of the heart, but of the sword; and in romance, at least, the quality of leech-craft (practised by the Lady Bountifuls of the last generation) was essential to the character of an accomplished princess. They sometimes trespassed on the province of their lovers, and actually took up arms. The Countess de Montfort in Bretagne is celebrated by Froissart for the gallantry with which she defended her castle, when besieged by the English; and the old Prior of Lochleven in Scotland is equally diffuse in the praise of Black Agnes, Countess of March, who, in the reign of Edward III. held out the castle of Dunbar against the English. She appeared on the battlements with a white handkerchief in her hands, and wiped the walls in derision where they had been struck by stones from the English engines. When Montagu, Earl of Salisbury, brought up to the walls a military engine, like the Roman *estudo*, called a sow, she exclaimed in rhime,

> Beware Montagou,
> For farrow shall thy sow.

A huge rock discharged from the battlements dashed the sow to pieces, and the English soldiers who escaped from its ruins were called by the Countess in derision Montague's pigs.

The nature of the conferences between these high-minded heroines and their lovers, was somewhat peculiar. Their delectations were in tales of warlike exploits, and in discourse of hunting and hawking. But when these topics were exhausted, they found in metaphysical discussions of nice questions concerning the passion of love, an endless source of interesting disquisition. The idea and definition of a true and pure passion, illustrated by an hundred imaginary cases devised on purpose, were managed in the same manner in which the schoolmen of

the day agitated their points of metaphysical theology. The Scotists and the Thomists, whose useless and nonsensical debates cumbered the world with so many volumes of absurd disquisition upon the most extravagant points of polemical divinity, saw their theological labours rivalled in the courts of love, where the most abstracted reasoning was employed in discussing subtle questions upon the exaggerated hopes, fears, doubts, and suspicions of lovers, the circumstances of whose supposed cases were often ridiculous, sometimes criminal, sometimes licentious, and almost always puerile and extravagant. These particulars will fall to be more fully illustrated under the article TROUBADOUR. In the meanwhile, it is sufficient to state, that the discussions in the Courts of Love regarded such important and interesting questions, as, Whether his love be most meritorious who has formed his passion entirely on hearing, or his who has actually seen his mistress? with others of a tendency equally edifying.

Extremes of every kind border on each other; and as the devotion of the knights of chivalry degenerated into superstition, the Platonic refinements and subtleties of amorous passion which they professed, were sometimes compatible with very coarse and gross debauchery. We have seen that they derived from the Gothic tribes that high and reverential devotion to the female sex, which forms the strongest tint in the manners of chivalry. But with the simplicity of these ancient times they lost their innocence; and woman, though still worshipped with enthusiasm as in the German forests, did not continue to be (in all cases at least) the same pure object of worship. The marriage-tie ceased to be respected; and as the youthful knights had seldom the means or inclination to encumber themselves with wives and families, their lady-love was often chosen among the married ladies of the court. It is true, that such a connection was supposed to be consistent with all respect and honour, and was regarded by the world, and sometimes by the husband, as a high strain of Platonic sentiment, through which the character of its object in no respect suffered. But nature vindicated herself for the violence offered to her; and while the metaphysical students and pleaders in the Courts of Love professed to aspire but to the lip or hand of their ladies, and to make a merit of renouncing all farther intrusion on their bounties, they privately indulged themselves in loves which had very little either of delicacy or sentiment. In the romance of the *Petit Jehan de Saintré*, that self-same Lady des Belles Cousines, who lectures so learnedly upon the seven mortal sins, not only confers on her deserving lover "le don d'amoureux merci," but enters into a very unworthy and disgraceful intrigue with a stout broad-shouldered abbot, into which no sentiment whatever can be supposed to enter. The romance of *Tirante the White*, praised by Cervantes as a faithful picture of the knights and ladies of his age, seems to have been written in an actual brothel, and, contrasted with others, may lead us to suspect that their purity is that of romance, its profligacy that of reality. This licence was greatly increased by the Crusades, from which the survivors of these wild expeditions brought back the corrupted morals of the east, to avenge the injuries they had inflicted on its inhabitants. Joinville has informed us of the complaints which Saint Louis made to him in confidence of the debaucheries practised in his own royal tent, by his attendants, in this holy expedition. And the ignominious punishment to which he subjected a knight, detected in such excesses, shows what severe remedies he judged necessary to stem the increase of libertinism.

Indeed, the gross licence which was practised during the middle ages, may be well estimated by the vulgar and obscene language that was currently used in tales and fictions addressed to the young and noble of both sexes. In the romance of the *Round Table*, as Ascham sternly states, little was to be learned but examples of homicide and adultery, although he had himself seen it admitted to the antichamber of princes, when it was held a crime but to be possessed of the Word of God. In the romance of *Amadis de Gaul*, and many others, the heroines, without censure or imputation, confer on their lovers the rights of a husband before the ceremony of the church gave them a title to the name. These are serious narrations, in which decorum, at least, is rarely violated. But the comic tales are of a grosser cast.

The *Canterbury Tales* of Chaucer contain many narratives of which, not only the diction, but the whole turn of the narrative, is extremely gross. Yet it does not seem to have occurred to the author, a man of rank and fashion, that they were improper to be recited, either in the presence of the prioress and her votaries, or in that of the noble knight who

> ——— of his port was meek as is a maid,
> And never yet no villany he said.

And he makes but a light apology for including the disasters of the *Millar of Trompington*, or of *Absalom the Gentle Clerk* in the same series of narrations with the *Knight's Tale*. Many of Bandello's most profligate novels are expressly dedicated to females of rank and consideration. And, to conclude, the *Fabliaux*, published by Barbazan and Le Grand, are frequently as revolting, from their naked grossness, as interesting from the lively pictures which they present of life and manners. Yet these were the chosen literary pastimes of the fair and the gay, during the times of Chivalry, listened to, we cannot but suppose, with an interest considerably superior to that exhibited by the yawning audience who heard the theses of the Courts of Love attacked and supported in logical form, and with metaphysical subtlety.

Should the manners of the times appear inconsistent in these respects which we have noticed, we must remember that we are ourselves variable and inconsistent animals, and that, perhaps, the surest mode of introducing and encouraging any particular vice, is to rank the corresponding virtue at a pitch unnatural in itself, and beyond the ordinary attainment of humanity. The vows of celibacy introduced profligacy among the Catholic clergy, as the high-flown and overstrained Platonism of the professors of Chivalry favoured the increase of licence and debauchery.

After the love of God and of his lady, the Preux

Chevalier was to be guided by that of glory and renown. He was bound by his vow to seek out adventures of risk and peril, and never to abstain from the quest which he might undertake, for any unexpected odds of opposition which he might encounter. It was not indeed the sober and regulated exercise of valour, but its fanaticism, which the genius of chivalry demanded of its followers. Enterprizes the most extravagant in conception, the most difficult in execution, the most useless when achieved, were those by which an adventurous knight chose to distinguish himself. There were solemn occasions also, on which these displays of chivalrous enthusiasm were specially expected and called for. It is only sufficient to name the tournaments, single combats, and solemn banquets, at which vows of chivalry were usually formed and proclaimed.

The tournaments were uniformly performed and frequented by the choicest and noblest youth in Europe, until the fatal accident of Henry II. after which they fell gradually into disuse. It was in vain that, from the various accidents to which they gave rise, these dangerous amusements were prohibited by the heads of the Christian church. The Popes, infallible as they were deemed, might direct, but could not curb the military spirit of chivalry; they could excite crusades, but they could not abolish tournaments. Their laws, customs, and regulations, will fall properly under a separate article. It is here sufficient to observe, that these military games were of two kinds. In the most ancient, meaning, " nothing in hate but all in honour," the adventurous knights fought with sharp swords and lances as in the day of battle. Even then, however, the number of blows was usually regulated, or, in case of a general combat, some rules were laid down to prevent too much slaughter. The regulations of Duke Theseus for the tournament in Athens, as narrated by Chaucer in the *Knight's Tale*, may give a good example of these restrictions. When the combatants fought on foot, it was prohibited to strike otherwise than at the head or body; the number of strokes to be dealt with the sword and battle-axe were carefully numbered and limited, as well as the careers to be run with the lance. In these circumstances alone, the combats at *outrance* as they were called, differed from encounters in actual war.

In process of time, the dangers of the solemn justs, held under the authority of princes, were modified by the introduction of arms of courtesy as they were termed, lances, namely, without heads, and with round braces of wood at the extremity called *rockets*, and swords without points, and with blunted edges. But the risk continued great from bruises, falls, and the closeness of the defensive armour of the times, in which the wearers were often smothered. The weapons at *outrance* were afterwards chiefly used when knights of different and hostile countries engaged by appointment, or when some adventurous gallants took upon them the execution of an enterprise of arms *(pas d'armes)* in which they, as challengers, undertook, for a certain time, and under certain conditions, to support the honour of their country or their mistress against all comers. These enterprises often ended fatally, but the knights who undertook them were received in the foreign countries which they visited in accomplishment of their challenge, with the highest deference and honour; their arrival was considered as affording a subject of sport and jubilee to all ranks; and when any mischance befel them, such as that of De Lindsay, who, in a tournament at Berwick, had his helmet nailed to his skull, by the truncheon of a lance which penetrated both, and died after devoutly confessing himself in the casque from which they could not disengage him, the knights who looked on prayed that God would vouchsafe them in his mercy a death so fair and so honourable. Stories of such challenges, with the minute details of the events of the combat, form frequent features in the histories of the age.

The contests of the tournament and the pas d'armes were undertaken merely in sport, and for thirst of honour. But the laws of the period afforded the adventurous knight other and more serious combats, in which he might exercise his valour. The custom of trying all doubtful cases by the body of a man, or, as it was otherwise expressed, by the judgment of God—in plain words, by referring the decision to the issue of a duel, prevailed universally among the Gothic tribes, from the highest antiquity. A *salvo* was devised, for the obvious absurdity of calling upon the weak to encounter the strong, a churchman to oppose a soldier, or age to meet in the lists with activity and youth. It was held that either party might appear personally, or by his champion. This sage regulation gave exercise for the valour of the knights, who were bound by their oaths to maintain the cause of those who had no other protector. And, indeed, there is good reason to think, that the inconveniences and injustice of a law so absurd in itself as that of judicial combat, were evaded and mitigated by the institutions of Chivalry, since, among the number of knights who were eagerly hunting after opportunities of military distinction, a party incapable of supporting his own cause by combat could have little difficulty in finding a formidable substitute; so that no one, however bold and confident, could prosecute an unjust cause to the uttermost, without the risk of encountering some champion of the innocent party from among the number of hardy knights who traversed every country seeking ostensible cause of battle.

Besides these formal combats, it was usual for the adventurous knight to display his courage by stationing himself at some pass in a forest, on a bridge, or elsewhere, compelling all passengers to avouch the superiority of his own valour, and the beauty of his mistress, or otherwise to engage with him in single combat. When Alexius Comnenus received the homage of the crusaders, seated upon his throne, previous to their crossing the Hellespont, during the first crusade, a French baron seated himself by the side of the Emperor of the East. He was reproved by Baldwin, and answered in his native language, " What ill-taught clown is this, who dares to keep his seat when the flower of the European nobility are standing around him!" The Emperor, dissembling his indignation, desired to know the birth and condition of the audacious Frank. " I am," replied the baron, " of the noblest race of France. For the rest, I only know that there is near my

castle a spot where four roads meet, and near it a church where men, desirous of single combat, spend their time in prayer till some one shall accept their challenge. Often have I frequented that chapel, but never met I one who durst accept my defiance." Thus the Bridge of Rodomont, in the Orlando Furioso, and the valiant defiance which the knight of La Mancha hurled against the merchants of Toledo, who were bound to the fairs of Murcia, were neither fictions of Ariosto nor Cervantes, but had their prototypes in real story. The chivalrous custom of defying all and sundry to mortal combat, subsisted in the borders until the days of Queen Elizabeth, when the worthy Bernard Gilpin found in his church of Houghton le Spring a glove hung over the altar, which he was informed indicated a challenge to all who should take it down. The remnants of the judicial combats, and the enterprizes of arms, may be found in the duels of the present day. In former days they still more resembled each other; for, in the seventeenth century, not only the seconds on each side regularly engaged, but it was usual to have more seconds, even to the number of five or six; a custom pleasantly ridiculed by Lord Chesterfield, in one of the papers of *The World*. It is obvious that an usage, at once so ridiculous and so detrimental to the peace and happiness of society must give way, in proportion to the progress of common sense. The custom is in general upon the wane, even as far as respects single combat between men who have actually given or taken offence at each other. The general rules of good-breeding prevent causes of such disagreement from arising in the intercourse of society, and the forward duellist, who is solicitous in seeking them out, is generally accounted a vulgar and ferocious, as well as a dangerous character. At the same time, the habits derived from the days of chivalry still retain a striking effect on our manners, and have fully established a graceful as well as useful punctilio, which tends on the whole to the improvement of society. Every man is under the impression, that neither his strength, his wealth, his station, or his wit, will excuse him from answering, at the risk of his life, any unbecoming encroachment on the civility due to the weakest, the poorest, the least important, or the most modest member of the society in which he mingles. All too in the rank and station of gentlemen are forcibly called upon to remember, that they must resent the imputation of a voluntary falsehood as the most gross injury; that the rights of the weaker sex demand protection from every one who would hold a good character in society. In short, from the wild and overstrained courtesies of chivalry has been derived our present system of manners. It is not certainly faultless, and it is guarded by penalties which we must often regret as disproportionably severe. Yet it has a grace and dignity unknown to classic times, when women were slaves, and men coarse and vulgar, or overbearing and brutal, as suited their own humour, without respect to that of the rest of their society

II. Such being the tone and spirit of chivalry, derived from love, devotion, and valour,—we have next to notice the special forms and laws of the order, which will be found to correspond in every respect to the spirit which they were designed to foster.

Rules and Forms of Chivalry.

The education of the future knight began at an early period. The care of the mother, after the first years of early youth were past, was deemed too tender, and the indulgences of the paternal roof too effeminate, for the future aspirant to the honours of chivalry. "Do you not bless God," said the Lady Mabel to her husband, the noble Duke Guerin of Montglaive, as on a solemn feast they looked on their four hopeful sons, "do you not bless God that has given you such a promising issue."—"Dame," replied Guerin, in the true spirit of the age, "so help me God and Saint Martin! nothing can do me greater despite than to look on these four great lurdanes, who, arrived at such an age, yet do nothing but eat the fat, and drink the sweet, and spend their time in idle amusement." * To counteract these habits of indulgence, the first step to the order of knighthood was the degree of Page.

The Page.

The young and noble stripling, generally about his twelfth year, was transferred from his father's house to that of some baron or noble knight, sedulously chosen by the anxious parent as that which had the best reputation for good order and discipline. The children of the first nobles and high crown-vassals were educated by the royal court. And, however the reins of discipline might be in particular cases relaxed, or become corrupted in latter days, the theory was uniformly excellent. The youth who was to learn modesty, obedience, and address in arms and horsemanship, was daily exercised in the use of arms, beginning with such as were suited to his strength. He was instructed how to manage a horse with grace and dexterity; how to use the bow and the sword; how to manage the lance, an art which was taught by making him ride a career against a wooden figure holding a buckler called a quintaine. This quintaine turned on an axis; and as there was a wooden sword in the other hand of the supposed opponent, the young cavalier, if he did not manage his horse and weapon with address, was liable to receive a blow when the shock of his charge made the quintaine spin round.

Besides these exercises, the noble youth was required to do the work which, in some respects, belonged to a menial, but not as a menial. He attended his lord during the chase, the rules of which, as an image of war, and as held the principal occupation of a gentleman during peace, were carefully inculcated. He was taught the principal blasts or notes of *venerie*, to be sounded when the hounds were uncoupled, when the prey was on foot, when he was brought to bay, and when he fell. This art did not tend solely to amusement. The "gentle damosel," to use the language of the times, learned to bear the fatigue, the hunger, and thirst, which huntsmen are exposed to. By the necessity of encountering and dispatching a stag, a boar, or a wolf, at bay, he learned promptitude and courage in the use of his weapons. The accuracy with which he was required to

* *L'Hystoire de Guerin de Montglaive.*

Chivalry. study the tracks of the hunted animal's course gave him habits of attention and reflection. In the days and nights spent in the chase, amid wide and pathless forests, he acquired the art, so necessary to a soldier, of remarking and studying the face of the country. When benighted, he was taught to steer his course by the stars, if they were visible; if not, to make his couch with patience on the withered leaves, or in a tree. Had he lost his way by day-time, he distinguished the points of the compass by remarking which side of the trees were most covered with moss, and from which they threw their branches most freely, circumstances which, compared with the known course of the prevailing wind, afforded him the necessary information.

The ceremonial of the chase was to be acquired as well as its arts. To brittle or break the deer, (in French, *faire la curée*), in plain terms, to flay and disembowel the stag, a matter in which much precision was required, and the rules of which were ascribed to the celebrated Sir Tristram of Lionesse, was an indispensable requisite of the page's education. Nor did his concern with the venison end here; he placed it on the table, waited during the banquet, and carved the ponderous dishes, when required or permitted to do so. Much grace and delicacy, it was supposed, might be displayed on these occasions; and, in one romance, we read of the high birth and breeding of a page being ascertained, by his scrupulously declining to use a towel to wipe his hands, when washed before he began to carve, and contenting himself with waving them in the air till they dried of themselves. It is, perhaps, difficult to estimate the force of this delicacy, unless by supposing that he had not a towel or napkin appropriated to his own separate use.

Amidst these various instructions, the page was often required to wait upon the ladies, rather as attending a sort of superior beings, to whom adoration and obsequious service were due, than as ministering to the convenience of human creatures like himself. The most modest demeanour, the most profound respect, was to be observed in the presence of these fair idols. Thus the veneration due to the female character was taught to the acolyte of chivalry, by his being placed so near female beauty, yet prohibited the familiarity which might discover female weakness. Love frequently mingled with this early devotion, and the connection betwixt some lady of distinction and her gallant knight, is often, in romantic fiction, supposed to have originated from such early affection. In a romance called *The Golden Thread*, (of which we have only seen a modern edition in German, but which has many features of originality), when the daughter of the Count bestows her annual gifts on her father's household, she gives the page Leofried, in derision, a single thread of gold tissue. To show the value which he places upon the most minute memorial, coming from such an hand, the youth opens a wound in his bosom, and deposits the precious thread in the neighbourhood of his heart. The Dame des belles Cousines, whom we have already mentioned, was assuredly not the only lady of high rank who was tempted to give a handsome young page the benefit of her experience in completing his education. This led the way to abuse; and the custom of breeding up youths as pages in the houses of the great, although it survived the decay of chivalry, was often rather the introduction to indolence, mischief, and debauchery, than to useful knowledge and the practice of arms. The proper purpose of this preliminary part of chivalrous education, are well given by one of the characters in Ben Jonson's *New Inn*, and he is answered by another, who alleges, with satire resembling that of Juvenal, the modern corruptions of the order of pages. Lord Lovel has requested mine Host to give him his son for a page. The Host answers, by declaring, he would rather hang his child with his own hand

> "Than damn him to that desperate course of life.
> *Lovel.* Call you that desperate which, by a line
> Of institution from our ancestors,
> Hath been derived down to us, and received
> In a succession, for the noblest way
> Of breeding up our youth in letters, arms,
> Fair mien, discourses, civil exercises,
> And all the blazon of a gentleman.
> Where can he learn to vault, to ride, to fence,
> To mar his body gracefully, to speak
> His language purer, or to turn his mind
> Or manners more to the harmony of nature
> Than in those nurseries of nobility?
> *Host.* Aye, that was when the nursery's self was noble,
> And only virtue made it not the market."

And he replies, by enumerating instances of the decay of honour among the nobles, and of the debauchery of their household pages. In La Noue's *Political and Military Discourses* is a similar complaint of the hazards to which the morals of young gentlemen were exposed while acting in this domestic capacity. Nevertheless, the custom of having young gentlemen thus bred, continued, in a certain degree, down to the last century, although those destined to such employments became, by degrees, of a lower quality. In some few instances, the institution was maintained in its purity, and the page, when leaving the family in which he was educated, usually obtained a commission. The last instance we know, was that of a gentleman bred a page in the family of the Duchess of Buccleuch and Monmouth, who died during the present reign, a general-officer in his Majesty's service.

The Squire. When advancing age and experience in the use of arms had qualified the page for the hardships and dangers of actual war, he was removed from the lowest to the second gradation of chivalry, and became an *Escuyer*, Esquire, or SQUIRE. The derivation of this phrase has been much contested. It has been generally supposed to be derived from its becoming the official duty of the esquire to carry the shield (*Escu*) of the knight his master, until he was about to engage the enemy. Others have fetched the epithet (more remotely certainly) from *Scuria* a stable, the charger of the knight being under the especial care of the squire. Others, again, ascribe the derivation of the word to the right which the squire himself had to carry a shield, and to blazon it with armorial bearings. This, in later times, became almost the exclusive meaning attached to the appellative esquire; and, accordingly, if the phrase now means anything, it means a gentleman having right to carry arms. There is reason, how-

ever, to think, that this is a secondary meaning of the word, for we do not find the word Escuyer, applied as a title of rank, until so late as the Ordonnance of Blois, in 1579.

The candidate for the honours of chivalry, now an immediate attendant on the knight or nobleman, was withdrawn from the private apartments of the ladies, and only saw them upon occasions of stated ceremony. In great establishments, there were squires of different ranks, and destined for different services; but we shall confine ourselves to those general duties which properly belonged to the office. The squire assisted his master in the offices at once of a modern valet de chambre and groom—he attended to dress and to undress him, trained his horses to the menage, and kept his arms bright and burnished. He did the honours of the household to the strangers who visited it, and the reputation of the prince or great lord whom he served, was much exalted by the manner in which these courteous offices were discharged. In the words of Chaucer, describing the character of the squire,

> "Curteis he was, lowly and servisable,
> And carf before his fader at the table."

The squire was also expected to perfect himself in the accomplishments of the period, and not only to be a master of the ceremonial of the feast, but to be capable of enlivening it by his powers of conversation. He was expected to understand chess, draughts, and other domestic games. Poetry and music, if he had any turn for these beautiful arts, and whatever other accomplishments could improve the mind or the person, were accounted to grace his station. And, accordingly, Chaucer's squire, besides that he was "singing or fluting all the day,"

> "—Could songs make, and well indite,
> Just, and eke dance, and well pourtray and write."

Unquestionably, few possessed all these attributes; but the poet, with his usual precision and vivacity, has given us the picture of a perfect esquire.

To understand the squires' mode of life more particularly, it is necessary to consider that which was led in the courts and castles of the middle ages. Froissart has given us a very striking account of the mode of house-keeping in the family of Gaston, Earl of Foix, a prince whose court was considered as a first-rate nursery for the noble youth; and, from his lively description, we may, in some measure, conceive the mode in which the esquires spent their time. Froissart abode in his house above twelve weeks, much recommended to the favourable notice of the earl, by his having brought with him a book containing all the songs, ballads, and virilays, which Wencislaus of Bohemia, the gentle Duke of Brabant, had made, and the historian himself had compiled or transcribed. "Every night, after supper," says Froissart, "I read thereon to him, and while I read there was none durst speak any thing to interrupt me, so much did the earl delight in listening." The quotation necessary to describe the Earl of Foix, and the economy of his household, must necessarily be a long one, but it is a picture, by the hand of an inimitable artist, of a school of chivalry when chivalry was at its highest pitch, and we are unwilling to destroy the likeness by abridging it.

"This erle Gascone of Foix, with whom I was, at that tyme, he was of a fyftie yere of age and nyne: and, I say, I have in my tyme sene many knights, kynges, princes, and others, but I neuer saw none like him of personage, nor of so fayre forme, nor so well made; his vysage fayre, sanguyne, and smylyng, his eyen gray and amorous, wher as he lyst to set his regarde: in euery thyng he was so parfite that he can not be praised to moche; he loued that ought to be beloued, and hated that ought to be hated: he was a wyse knyght, of highe enterprise, and of good counsayle; he neuer had myscreant with hym; he sayd many orisons every day, a nocturn of the psalter, matyns of our Lady, of the Holy Goost, and of the crosse, and dirigè euery day; he gaue fyue florins, in small monies, at his gate to poore folkes for the loue of God; he was large and courtesse in gyftes; he could ryght well take where it parteyned to hym, and to delyuer agayne wher as he ought; he loued hoũdes of all beestes, wynter and somer he loued huntyng; he neuer loued folly, outrage, nor foly larges; euery moneth he wolde knowe what he spended; he tooke in his countre to receyue his reuenwes, and to serue him, notable persons, that is to saye, xii. recyuours, and euer fro 11. monethes to two monethes, two of them shulde serue for his receyte; for, at the two monethes ende, he wolde change and put other two into that offyce; and one that he trusted best shulde be his comptroller, and to hym all other shulde accompt, and the comptroller shulde accõpt to hym by rolles and bokes written, and the comptes to remayne still with therle: he had certeyne cofers in his chambre, out of the whiche oftetymes he wolde take money to gyve to lordes, knightes, and squyers, suche as came to hym, for none shulde departe from him without some gift, and yet dayly he multiplyed his treasure, to resyst the aduẽtures and fortunes that he douted; he was of good and easy acquayntance with every man, and amorously wolde speke to thẽ; he was short in counsayle, and answers; he had four secretaries, and at his rising, they must ever be redy at his hande, without any callynge; and whan any letter were delyuered him, and that he had reed it, than he wolde calle them to write agayne, or els for some other thynge. In this estate therle of Foix lyued. And at mydnight, whan he came out of his chambre into the hall to supper, he had ever before hym xii. torches brennyng, borne by xii. varlettes standyng before his table all supper; they gaue a gret light, and the hall ever full of knightes and squyers, and many other tables dressed to suppe who wolde; ther was none should speke to hym at his table, but if he were called; his meate was lightlye wylde foule, the legges and wynges alonely, and in the day he dyd but lytell eate and drĩke; he had great pleasure in armony of instrumẽtes; he coude do it right well hymselfe, he wolde have songes song before him, he wolde gladlye se conseytes and fantesies at his table. And or I came to his court, I had ben in many courtes of kynges, dukes, princes, erles, and great ladyes, but I was neuer in none y so well liked me, nor ther was

onne more reioysed in dedes of armes, than the erle dyde: ther was sene in his hall, chãbre and court, knightes and squyers of honour goyng up and downe, and talking of armes and amours; all honour ther was found, all maner of tidynges of every realme and countre ther might be herde, for out of every coũtre there was resort, for the valyantnesse of this erle." *

While the courage of the young aspirant to the honours of knighthood was animated, and his emulation excited by the society in which he was placed, and the conversation to which he listened,—while everything was done which the times admitted to refine his manners, and, in a certain degree, to cultivate his understanding; the personal exercises to which he had been trained, while a page, were now to be pursued with increasing assiduity, proportional to the increase of his strength. "He was taught," says a historian, speaking of Bouçicaut, while a squire "to spring upon a horse, while armed at all points; to exercise himself in running, to strike for a length of time with the axe or club; to dance and throw somersets, entirely armed, excepting the helmet; to mount on horseback behind one of his comerades, by barely laying his hands on his sleeve; to raise himself betwixt two partition walls to any height, by placing his back against the one, and his knees and hands against the other; to mount a ladder, placed against a tower, upon the reverse or under side, solely by the aid of his hands, and without touching the rounds with his feet; to throw the javelin, to pitch the bar," to do all, in short, which could exercise the body to feats of strength and agility, in order to qualify him for the exploits of war. For this purpose, also the esquires had their tourneys separate and distinct from those of the knights. They were usually solemnized on the eve of the more formal and splendid tournaments, in which the knights themselves displayed their valour; and lighter weapons, than those of the knights, though of the same kind, were employed by the esquires. But, as we shall presently notice, the most distinguished among the esquires were (notwithstanding the high authority of the knight of La Mancha to the contrary) frequently admitted to the honours and dangers of the more solemn encounter.

In actual war the page was not expected to render much service, but that of the squire was important and indispensable. Upon a march he bore the helmet and shield of the knight and led his horse of battle, a tall heavy animal fit to bear the weight of a man in armour, but which was led in hand upon a march, while the knight rode an ambling hackney. The squire was also qualified to perform the part of an armourer, not only lacing his master's helmet and buckling his cuirass, but also closing with a hammer the rivets by which the various pieces were united to each other. This was a point of the utmost consequence; and many instances occur of mischances happening to celebrated warriors when the duty was negligently performed. In the actual shock of battle, the esquire attended closely on the banner of his master, or on his person if he were only a knight bachelor, kept pace with him during the melée, and was at hand to remount him when his steed was slain, or relieve him when oppressed by numbers. If the knight made prisoners they were the charge of the esquire; if the esquire himself fortuned to make one, the ransom belonged to his master.

On the other hand, the knights who received these important services from their esquires, were expected to display towards them that courteous liberality which made so distinguished a point of the chivalrous character. Lord Audley led the van of the Black Prince's army at the battle of Poitiers, attended by four squires who had promised not to fail him. They distinguished themselves in the front of that bloody day, leaving such as they overcame to be made prisoners by others, and ever pressing forwards where resistance was offered. Thus they fought in the chief of the battle until Lord James Audley was sorely wounded, and his breath failed him. At the last, when the battle was gained, the four faithful esquires bore him out of the press, disarmed him, and staunched and dressed his wounds as they could. As the Black Prince called for the man to whom the victory was in some measure owing, Lord Audley was borne before him in a litter, when the prince, after having awarded to him the praise and renown above all others who fought on that day, bestowed on him five hundred marks of yearly revenue, to be assigned out of his heritage in England. Lord Audley accepted of the gift with due demonstration of gratitude; but no sooner was he brought to his lodging than he called before him the four esquires by whom he had been so gallantly seconded, and the nobles of his lineage, and informed his kinsmen, "Sirs, it hath pleased my Lord the Prince to bestow on me five hundred marks of heritage of which I am unworthy, for I have done him but small service. Behold, Sirs, these four squires, which have always served me truly, and specially this day; the honour that I have is by their valour. Therefore I resign to them and their heirs forever, in like manner as it was given to me, the noble gift which the Prince hath assigned me." The lords beheld each other, and agreed it was a proof of great chivalry to bestow so royal a gift, and gladly undertook to bear witness to the transfer. When Edward heard these tidings, he sent for Lord Audley, and desired to know why he had bestowed on others the gift he had assigned him, and whether it had not been acceptable to him: "Sir," said Lord Audley, "these four squires have followed me well and truly in several severe actions, and at this battle they served me so well, that had they done nothing else, I had been bound to reward them. I am myself but a single man, but, by aid of their united strength and valour, I was enabled to execute the vow which I had made to give the onset in the first battle in which the King of England or his sons should be pre-

* Froissart's *Chronicles*, translated by Lord Berners.

Chivalry.

sent, and had it not been for them, I must have been left dead on the field. This is the reason I have transferred your Highnesses bounty, as to those by whom it was best deserved." The Black Prince not only approved of and confirmed Lord Audley's grant, but conferred upon him, not to be outdone in generosity, an yearly revenue of six hundred marks more, for his own use.* The names of the esquires, who thus distinguished themselves, and experienced such liberality at the hands of their leader, were Delves of Doddington, Dutton of Dutton, Fowlishurst of Crewe, and Hawkestone of Wreynehill, all Cheshire families. This memorable instance may suffice to show the extent of gratitude which the knights entertained for the faithful service of their squires. But it also leads us to consider some other circumstances relating to the order of esquire.

Although, in its primitive and proper sense, the state of esquire was merely preparatory to that of knighthood, yet it is certain that many men of birth and property rested content with attaining that first step; and, though greatly distinguished by their feats of arms, never rose, nor apparently sought to rise, above the rank which it conferred. It does not appear that any of the esquires of Lord Audley were knighted after the battle of Poitiers, although there can be no doubt that their rank, as well as their exploits, entitled them to expect that honour. The truth seems to be, that it may frequently have been more convenient, and scarcely less honourable, to remain in the unenvied and unpretending rank of esquire, than to aspire to that of knighthood, without a considerable fortune to supply the expences of that dignity. No doubt, in theory, the simplest knight bachelor was a companion, and in some degree equal, with princes. But, in truth, we shall presently see, that, where unsupported by some sort of income to procure suitable equipment and retainers, that dignity was sometimes exposed to ridicule. Many gallant gentlemen, therefore, remained esquires, either attached to the service of some prince or eminent nobleman, or frequently in a state of absolute independence, bringing their own vassals to the field, whom, in such cases, they were entitled to muster under a *Penoncele*, or small triangular streamer, somewhat like the naval pendant of the present day. The reader of history is not, therefore, to suppose, that, where he meets with an esquire of distinguished name, he is therefore, necessarily, to consider him as a youthful candidate for the honour of knighthood, and attending upon some knight or noble. This is, indeed, the primitive, but not the uniform meaning of the title. So many men of rank and gallantry appear to have remained esquires, that, by degrees, many of the leading distinctions between them and the knights were relaxed or abandoned. In Froissart's *Chronicles*, we find that esquires frequently led independent bodies of men, and, as we have before hinted, mingled with the knights in the games of chivalry; the difference chiefly consisting in title, precedence, the shape of the flag under which they arrayed their followers, and the fashion of their armour. The esquires were permitted to bear a shield, emblazoned, as we have already seen, with armorial bearings. There seems to have been some difference in the shape of the helmet; and the French esquire was not permitted to wear the complete hauberk, but only the shirt of mail, without hood or sleeves. But the principal distinction between the independent esquire (terming him such who was attached to no knight's service) and the knight, was the spurs, which the esquire might wear of silver, but by no means gilded.

To return to the esquires most properly so termed, their dress was, during their period of probation, simple and modest, and ought regularly to have been made of brown, or some other uniform and simple colour. This was not, however, essential. The garment of Chaucer's squire was embroidered like a meadow. The petit Jehan de Saintré was supplied with money by his mistress to purchase a silken doublet and embroidered hose. There is also a very diverting account in the *Memoirs of Bertrand de Guesclin* of the manner in which he prevailed on his uncle, a covetous old churchman, to assign him money for his equipment on some occasion of splendour. We may therefore hold, that the sumptuary laws of squirehood were not particularly attended to, or strictly enforced.

A youth usually ceased to be a page at fourteen, or a little earlier, and could not regularly receive the honour of knighthood until he was one and twenty. But, if their distinguished valour anticipated their years, the period of probation was shortened. Princes of the blood royal, also, and other persons of very high eminence, had this term abridged, and sometimes so much so as to throw a ridicule upon the order of knighthood, by admitting within "the temple of honour," as it was the fashion of the times to call it, children who could neither understand nor discharge the duties of the office to which they were thus prematurely called.

Knights.

The third and highest rank of chivalry was that of Knighthood. In considering this last dignity, we shall first inquire, how it was conferred; secondly, the general privileges and duties of the order; thirdly, the peculiar ranks into which it was finally divided, and the difference betwixt them.

The Investiture.

Knighthood was, in its origin, an order of a republican, or at least an oligarchic nature; arising, as has been shown, from the customs of the free tribes of Germany, and, in its essence, not requiring the sanction of a monarch. On the contrary, each knight could confer the order of knighthood upon whomsoever preparatory noviciate and probation had fitted to receive it. The highest potentates sought the *accolade*, or stroke which conferred the honour, at the hands of the worthiest knight whose achievements had dignified the period. Thus Francis I. requested the celebrated Bayard, the *Good Knight without reproach or fear*, to make him; an honour which Bayard valued so highly, that, on sheathing his sword, he vowed never more

* Froissart. Barne's *History of Edward III.*

to use that blade, except against Turks, Moors, and Saracens. The same principle was carried to extravagance in a romance, where the hero is knighted by the hand of Sir Lancelot of the Lake, when dead. A sword was put into the hand of the skeleton, which was so guided as to let it drop on the neck of the aspirant. In the time of Francis I. it had already become customary to desire this honour at the hands of greatness rather than valour, so that the King's request was considered as an appeal to the first principles of chivalry. In theory, however, the power of creating knights was supposed to be inherent in every one who had reached that dignity. But it was natural that the soldier should desire to receive the highest military honour from the general under whose eye he was to combat, or from the prince or noble at whose court he passed as page and squire through the gradations of his noviciate. It was equally desirable, on the other hand, that the prince or noble should desire to be the immediate source of a privilege so important. And thus, though no positive regulation took place on the subject, ambition on the part of the aspirant, and pride and policy on that of the sovereign princes and nobles of high rank, gradually limited to the latter the power of conferring knighthood, or drew at least an unfavourable distinction between the knights dubbed by private individuals, and those who, with more state and solemnity, received the honoured title at the hand of one of high rank. Indeed, the change which took place respecting the character and consequences of the ceremony, naturally led to a limitation in the right of conferring it. While the order of knighthood merely implied a right to wear arms of a certain description, and to bear a certain title, there could be little harm in entrusting, to any one who had already received the honour, the power of conferring it on others. But when this highest order of chivalry conferred not only personal dignity, but the right of assembling under the banner, or pennon, a certain number of soldiers, when knighthood implied not merely personal privileges, but military rank, it was natural that sovereigns should use every effort to concentrate the right of conferring such distinction in themselves, or their immediate delegates. And latterly it was held, that the rank of knight only conferred those privileges on such as were dubbed by sovereign princes.

The times and place usually chosen for the creation of knights, was favourable to the claim of the sovereigns to be the proper fountain of chivalry. Knights were usually made either on the eve of battle, or when the victory had been obtained; or they were created during the pomp of some solemn warning or grand festival. In the former case, the right of creation was naturally referred to the general or prince who led the host; and, in the latter, to the sovereign of the court where the festival was held. The forms in these cases were very different.

When knights were made in the actual field of battle, little solemnity was observed, and the form was probably the same with which private individuals had, in earlier times, conferred the honour on each other. The novice, armed at all points, but without helmet, sword, and spurs, came before the prince or general, at whose hands he was to receive knighthood, and kneeled down, while two persons of distinction, who acted as his godfathers, and were supposed to become pledges for his being worthy of the honour to which he aspired, buckled on his gilded spurs, and belted him with his sword. He then received the accolade, a slight blow on the neck, with the flat of the sword, from the person who dubbed him, who, at the same time, pronounced a formula to this effect: "I dub thee, knight, in the name of God and St Michael (or in the name of the Father, Son, and Holy Ghost). Be faithful, bold, and fortunate." The new made knight had then only to take his place in the ranks of war, and endeavour to distinguish himself by his forward gallantry in the approaching action, when he was said to win his spurs. It is well known, that, at the battle of Cressy, Edward III. refused to send succours to the Black Prince, until he should hear that he was wounded or dismounted, being determined he should, on that memorable day, have full opportunity to *win his spurs*. It may be easily imagined, that, on such occasions, the courage of the young knights was wound up to the highest pitch, and, as many were usually made at the same time, their gallantry could not fail to have influence on the fortune of the day. At the siege of Tholouse (1159), Henry II. of England made thirty knights at once, one of whom was Malcolm IV. King of Scotland. Even, on these occasions, the power of making knights was not understood to be limited to the commander in chief. At the fatal battle of Homildown, in 1401, Sir John Swinton, a warrior of distinguished talents, observing the slaughter made by the English archery, exhorted the Scots to rush on to a closer engagement. Adam Gordon, between whose family and that of Swinton a deadly feud existed, hearing this sage council, knelt down before Swinton, and prayed him to confer on him the honour of knighthood, which he desired to receive from the wisest and boldest knight in the host. Swinton conferred the order; and they both rushed down upon the English host followed only by a few cavalry. If they had been supported the attack might have turned the fate of the day. But none followed their gallant example, and both champions fell. It need hardly be added, that the commander, whether a sovereign prince or not, equally exercised the privilege of conferring knighthood. In the old ballad of the battle of Otterburn, Douglas boasts that, since he had entered England, he had

"With brand dubb'd many a knight."

But it was not in camps and armies alone that the honours of knighthood were conferred. At the *Cour Pleniere*, a high court to which sovereigns summoned their crown vassals at the solemn festivals of the church, at the various occasions of solemnity which occurred in the royal family, from marriage, birth, baptism, and the like, the monarch was wont to confer on novices in chivalry its highest honour, and the ceremonies used on such investiture added to the dignity of the occasion. It was then that the full ritual was observed which, on the eve of battle, was necessarily abridged or omitted. The candidates watched their arms all night in a church or chapel, and prepared for the honour to be conferred on them, by vigil, fast, and prayer. They were solemnly divested of the brown frock, which was the appropriate

Chivalry. dress of the squire, and having been bathed, as a symbol of purification of heart, they were attired in the richer garb appropriate to knighthood. They were then solemnly invested with the appropriate arms of a knight; and it was not unusual to call the attention of the novice to a mystical or allegorical explanation of each piece of armour as it was put on. These exhortations consisted in strange and extravagant parallels betwixt the temporal and spiritual state of warfare, in which the metaphor was hunted down in every possible shape. The under dress of the knight was a close jacket of chamois leather, over which was put the mail shirt, composed of rings of steel artificially fitted into each other, as is still the fashion in some parts of Asia. A suit of plate armour was put on over the mail shirt, and the legs and arms were defended in the same manner. Even this accumulation of defensive armour, was by some thought insufficient. In the combat of the Infantes of Carrion with the champions of the Cid, one of the former was yet more completely defended, and to little purpose.

Onward into Ferrand's breast, the lance's point is driven
Full upon his breastplate, nothing would avail;
Two breastplates Ferrand wore, and a coat of mail,
The two are riven in sunder, the third stood him in stead,
The mail sunk in his breast, the mail and the spear head;
The blood burst from his mouth, that all men thought him dead.*

The novice being accoutred in his knightly armour, but without helmet, sword, and spurs, a rich mantle was flung over him, and he was conducted in solemn procession to the church or chapel in which the ceremony was to be performed, supported by his godfathers, and attended with as much pomp as circumstances admitted. High mass was then said, and the novice, advancing to the altar, received from the sovereign the accolade. The churchman present, of highest dignity, often belted on his sword, which, for that purpose, had been previously deposited on the altar, and the spurs were sometimes fastened on by ladies of quality. The oath of chivalry was then taken, to be loyal to God, the king, and the ladies. Such were the outlines of the ceremony, which, however, was varied according to circumstances. A king of Portugal knighted his son in presence of the dead body of the Marquis of Marialva, slain in that day's action, and impressively conjured the young prince to do his duty in life and death like the good knight who lay dead before him. Alms to the poor, largesses to the heralds and minstrels, a liberal gift to the church, were necessary accompaniments to the investiture of a person of rank. The new made knight was conducted from the church with music and acclamations, and usually mounted his horse and executed some curvets in presence of the multitude, couching his lance, and brandishing it as if impatient to open his knightly career. It was at such times, also, that the most splendid tournaments were executed, it being expected that the young knights would display the utmost efforts to distinguish themselves. Such being the solemnities with which knighthood was conferred, it is no wonder that the power of conferring it should, in peace as well as in war, be almost confined to sovereign princes, or nobles who nearly equalled them in rank and independence. By degrees these restrictions were drawn more and more close, and at length it was held that none but a sovereign or a commander-in-chief, displaying the royal banner, and vested with plenary and vice-regal authority, could confer the degree of knighthood. Queen Elizabeth was particularly jealous of this part of her prerogative, and nothing more excited her displeasure and indignation against her favourite Essex, than the profuseness with which he distributed the honour at Cadiz, and afterwards in Ireland. These anecdotes, however, belong to the decay of chivalry.

Arms and Privileges of a Knight.

The knight had several privileges of dignity and importance. He was associated into a rank wherein kings and princes were in one sense only his equals. He took precedence in war and in counsel, and was addressed by the respectful title of *Messire* in French and *Sir* in English, and his wife by that of Madame and Dame. A knight was also, in point of military rank, qualified to command any body of men under a thousand. His own service was performed on horseback and in complete armour, of many various fashions, according to the taste of the warriors and the fashion of the age. Chaucer has enumerated some of these varieties.

"With him ther wenten knights many on.
Som wol ben armed in an habergeon,
And in a brest plate, and in a gipon;
And som wol have a pair of plates large;
And som wol have a pruse sheld, or a targe;
Some wol ben armed on his legges wele,
And have an axe, and some a mace of stele.
Ther n'is no newe guise, that it n'as old.
Armed they weren, as I have you told,
Everich after his opinion."

The weapons of offence, however, most appropriate to knighthood were the lance and sword. They had frequently a battle axe or mace at their saddle-bow, a formidable weapon even to men sheathed in iron like themselves. The knight had also a dagger which he used when at close quarters. It was called the dagger of mercy, probably because, when unsheathed, it behoved the antagonist to crave mercy or to die. The management of the lance and of the horse was the principal requisite of knighthood. To strike the foeman either on the helmet or full upon the breast with the point of the lance, and at full speed, was accounted perfect practice; to miss him, or to break a lance across, *i. e.* athwart the body of the antagonist, without striking him with the point, was accounted an awkward failure; to strike his horse, or to hurt his person under the girdle, was conceived a foul or felon action, and could only be excused by the hurry of a general encounter. When the knights, from the nature of the ground, or other circumstances, alighted to fight on foot, they used to cut some part from the length of their spears, in order to render them more manage-

* See Translations from the Spanish metrical Romance on the subject of the Cid appended to Mr Southey's Cid.

able, like the pikes used by infantry. But their most formidable onset was when mounted and "in host." They seem then to have formed squadrons not unlike the present disposition of cavalry in the field,—their squires forming the rear-rank, and performing the part of serrefiles. As the horses were trained in the tourneys and exercises to run upon each other without flinching, the shock of two such bodies of heavy-armed cavalry was dreadful, and the event usually decided the battle; for, until the Swiss showed the superior steadiness which could be exhibited by infantry, all great actions were decided by the men at arms. The yeomanry of England, indeed, formed a singular exception; and, from the dexterous use of the long bow, to which they were trained from infancy, were capable of withstanding and destroying the mail-clad chivalry both of France and Scotland. Their shafts, according to the exaggerating eloquence of a monkish historian, Thomas of Walsingham, penetrated steel coats from side to side, transfixed helmets, and even splintered lances and pierced through swords! But, against every other pedestrian adversary, the knights, squires, and men-at-arms had the most decided advantage, from their impenetrable armour, the strength of their horses, and the fury of their onset. To render success yet more certain, and attack less hazardous, the horse, on the safety of which the riders so much depended, was armed en-barbe, as it was called, like himself. A masque made of iron covered the animal's face and ears; it had a breast-plate, and armour for the croupe. The strongest horses were selected for this service; they were generally stallions, and to ride a mare was reckoned base and unknightly.

To distinguish him in battle, as his face was hid by the helmet, the knight wore above his armour a surcoat, as it was called, like a herald's coat, on which his arms were emblazoned. Others had them painted on the shield, a small triangular buckler of light wood, covered with leather, and sometimes plated with steel, which, as best suited him, the knight could either wield on his left arm, or suffer to hang down from his neck, as an additional defence to his breast, when the left hand was required for the management of the horse. The shape of these shields is preserved, being that on which heraldric coats are most frequently blazoned. But it is something remarkable, that no one of those *heater* * shields has been preserved in the Tower, or, so far as we know, in any English collection. The helmet was surmounted by a crest, which the knight adopted after his own fancy. There was deadly offence taken if one knight, without right, assumed the armorial bearings of another; and history is full of disputes on that head, some of which terminated fatally. The heralds were the persons appealed to on these occasions, when the dispute was carried on in peace, and hence flowed the science, as it was called, of heraldry, with all its fantastic niceties. By degrees the crest and device became also hereditary, as well as the bearings on the shield. In addition to his armorial bearings, the knight distinguished himself in battle by shouting out his war-cry, which was echoed by his followers. It was usually the name of some favourite saint, united with that of his own family. If the knight had followers under his command, they re-echoed his war-cry, and rallied round his pennon or flag at the sound. The pennon differed from the penoncel, or triangular streamer which the squire was entitled to display, being double the breadth, and indented at the end like the tail of a swallow. It presented the appearance of two penoncels united at the end next the staff, a consideration which was not perhaps out of view in determining its shape. Of course, the reader will understand that those knights only displayed a pennon who had retainers to support and defend it, the mounting this ensign being a matter of privilege, not of obligation.

Froissart's heart never fails to overflow when he describes the encounter of a body of men at arms, arrayed in the manner we have described; he dwells with enthusiasm on the leading circumstances. The waving of banners and pennons, the dashing of spurs into the sides of chargers, and their springing forward to battle; the glittering of armour, the glancing of plumes, the headlong shock and splintering of the lances, the swords flashing though the dust over the heads of the combatants, the thunder of the horses' feet and the clash of armour, mingled with the war-cry of the combatants and the groans of the dying, form the mingled scene of tumult, strife, and death, which the Canon has so frequently transferred to his chivalrous pages.

It was not in war alone that the adventurous knight was to acquire fame. It was his duty, as we have seen, to seek adventures throughout the world, whereby to exalt his own fame and the beauty of his mistress, which inspired such deeds. In our remarks upon the general spirit of the institution, we have already noticed the frantic enterprizes which were seriously undertaken and punctually executed by knights desirous of a name. On these occasions, the undertaker of so rash an enterprize often owed his life to the sympathy of his foes, who had great respect for any one engaged in the discharge of a vow of chivalry. When Sir Robert Knowles passed near Paris, at the head of an English army, in the reign of Edward III., the following remarkable incident took place:

"Now it happened, one Tuesday morning, when the English began to decamp, and had set fire to all the villages wherein they were lodged, so that the fires were distinctly seen from Paris, a knight of their army, who had made a vow, the preceding day, that he would advance as far as the barriers and strike them with his lance, did not break his oath, but set off with his lance in his hand, his target on his neck, and completely armed except his helmet, and, spurring his steed, was followed by his squire on another courser, carrying the helmet. When he approached Paris, he put on the helmet, which his squire laced behind. He then galloped away, sticking spurs into his horse, and advanced prancing

* So called because resembling in shape the heater of a smoothing-iron.

to strike the barriers. They were then open, and the lords and barons within imagined he intended to enter the town; but he did not so mean, for having struck the gates according to his vow, he checked his horse and turned about. The French knights who saw him thus retreat, cried out to him, 'Get away! get away! thou hast well acquitted thyself.' As for the name of this knight, I am ignorant of it, nor do I know from what country he came; but he bore for his arms gules à deux fousses noir, with une bordure noir non endentée.

"However, an adventure befel him, from which he had not so fortunate an escape. On his return he met a butcher on the pavement in the suburbs, a very strong man, who had noticed him as he had passed him, and who had in his hand a very sharp and heavy hatchet with a long handle. As the knight was returning alone, and in a careless manner, the valiant butcher came on one side of him, and gave him such a blow between the shoulders, that he fell on his horse's neck: he recovered himself, but the butcher repeated the blow on his head, so that the axe entered it. The knight, through excess of pain, fell to the earth, and the horse galloped away to the squire, who was waiting for his master in the fields at the extremity of the suburbs. The squire caught the courser, but wondered what was become of his master; for he had seen him gallop to the barriers, strike them, and then turn about to come back. He therefore set out to look for him; but he had not gone many paces before he saw him in the hands of four fellows, who were beating him as if they were hammering on an anvil. This so much frightened the squire, that he dared not advance further, for he saw he could not give him any effectual assistance; he therefore returned as speedily as he could.

"Thus was this knight slain: and those lords who were posted at the barriers had him buried in holy ground. The squire returned to the army, and related the misfortune which had befallen his master. All his brother-warriors were greatly displeased thereat." (Johnes's *Froissart*, Vol. II. p. 63.)

An equally singular undertaking was that of Galeazzo of Mantua, as rehearsed by the venerable Doctor Paris de Puteo, in his treatise *De Duello et re Militari*, and by Brantome in his *Essay on Duels*. Queen Joan of Naples, at a magnificent feast given in her castle of Gaeta, had given her hand to Galeazzo, for the purpose of opening the ball. The dance being finished, the gallant knight kneeled down before his royal partner, and, in order to make fitting acknowledgment of the high honour due him, took a solemn vow to wander through the world wherever deeds of arms should be exercised, and not to rest until he had subdued two valiant knights, and had presented them prisoners at her royal footstool, to be disposed of at her pleasure. Accordingly, after a year spent in visiting various scenes of action in Brittany, England, France, Burgundy, and elsewhere, he returned like a falcon with his prey in his clutch, and presented two prisoners of knightly rank to Queen Joan. The queen received the gift very graciously; and, declining to avail herself of the right she had to impose rigorous conditions on the captives, she gave them liberty without ransom, and bestowed on them, over and above, several marks of liberality. For this she is highly extolled by Brantome and Dr Paris, who take the opportunity of censuring the very opposite conduct of the Canons of Saint Peter's Church at Rome, upon whom a certain knight had bestowed a prisoner taken in single combat. These ungracious churchmen received the gift as if it had been that of a wild beast for a menagerie, permitting the poor captive the freedom of the church indeed, but prohibiting him to go one step beyond the gate. In which condition, worse than death, they detained the vanquished knight for some time, and were justly blamed, as neither understanding Christian charity nor gentleman-like courtesy.

We return to consider the duties of a knight. His natural and proper element was war. But in time of peace when there was no scope for the fiery spirit of chivalry, the knights attended the tourneys proclaimed by different princes, or, if these amusements did not occur, they themselves undertook feats of arms, to which they challenged all competitors. The nature of these challenges will be best understood from an abridged account of the *pas d'armes*, called the *Justs* of Saint Inglebert, or Sandyng fields. This emprize was sustained by three gallant knights of France, Bouçicaut, Reynold de Roy, and Saint Py or Saimpi. Their articles bound them to abide thirty days at Saint Inglebert, in the marches of Calais, there to undertake the encounter of all knights and squires, Frenchmen, or strangers, who should come hither, for the breaking of five spears, sharp, or with rockets, at their pleasure. On their lodgings they hung two shields called of peace and war, with their armorial blazons on each. The stranger desiring to just was invited to come or send, and touch which shield he would. The weapons of courtesy were to be employed if he chose the shield of peace, if that of war, the defenders were to give him the desired encounter with sharp weapons. The stranger knights were invited to bring some nobleman with them, to assist in judging the field, and the proclamation concludes with an entreaty to knights and squires strangers, that they will not hold this offer as made for any pride, hatred, or ill-will; but only that the challengers do it to have their honourable company and acquaintance, which, with their whole heart, they desire. They were assured of a fair field, without fraud or advantage; and it was provided, that the shields used should not be covered with iron or steel. The French King was highly joyful of this gallant challenge (although some of his council doubted the wisdom of permitting it to go forth), and exhorted the challengers to regard the honour of their prince and realm, and spare no cost at the solemnity, for which he was willing to contribute ten thousand franks. A number of knights and squires came from England to Calais to accept this gallant invitation; and at the entrance of the "fresh and joly month of May," the challengers pitched three green pavilions in a fair plain between Calais and the Abbey of Saint Inglebert. Two shields hung before each pavilion, with the arms of the owner.

"On the 21st of the month of May, as it had been proclaimed, the three knights were properly armed

and their horses properly saddled, according to the laws of the tournament. On the same day, those knights who were in Calais sallied forth, either as spectators or tilters, and, being arrived at the spot, drew up on one side. The place of the tournament was smooth, and green with grass.

"Sir John Holland was the first who sent his squire to touch the war-target of Sir Bouçicaut, who instantly issued from his pavilion completely armed. Having mounted his horse, and grasped his spear, which was stiff and well steeled, they took their distances. When the two knights had for a short time eyed each other, they spurred their horses, and met full gallop with such a force that Sir Bouçicaut pierced the shield of the Earl of Huntingdon, and the point of his lance slipped along his arm, but without wounding him. The two knights, having passed, continued their gallop to the end of the list. This course was much praised. At the second course, they hit each other slightly, but no harm was done; and their horses refused to complete the third.

"The Earl of Huntingdon, who wished to continue the tilt, and was heated, returned to his place, expecting that Sir Bouçicaut would call for his lance; but he did not, and showed plainly he would not that day tilt more with the earl. Sir John Holland, seeing this, sent his squire to touch the war-target of the Lord de Saimpi. This knight, who was waiting for the combat, sallied out from his pavilion, and took his lance and shield. When the earl saw he was ready, he violently spurred his horse, as did the Lord de Saimpi. They couched their lances, and pointed them at each other. At the onset, their horses crossed; notwithstanding which, they met; but by this crossing, which was blamed, the earl was unhelmed. He returned to his people, who soon rehelmed him; and having resumed their lances, they met full gallop, and hit each other with such a force in the middle of their shields, they would have been unhorsed had they not kept tight seats by the pressure of their legs against their horses' sides. They went to the proper places, where they refreshed themselves, and took breath.

"Sir John Holland, who had a great desire to shine at this tournament, had his helmet braced, and regrasped his spear; when the Lord de Saimpi, seeing him advance on the gallop, did not decline meeting, but, spurring his horse on instantly, they gave blows on their helmets, that were luckily of well-tempered steel, which made sparks of fire fly from them. At this course, the Lord de Saimpi lost his helmet; but the two knights continued their career, and returned to their places.

"This tilt was much praised, and the English and French said, that the Earl of Huntingdon, Sir Bouçicaut, and the Lord de Saimpi, had excellently well justed, without sparing or doing themselves any damage. The Earl wished to break another lance in honour of his lady, but it was refused him. He then quitted the lists to make room for others, for he had run his six lances with such ability and courage as gained him praise from all sides." (Johnes's *Froissart*, Vol. IV. p. 143.)

The other justs were accomplished with similar spirit. Sir Peter Courtney, Sir John Russell, Sir Peter Sherburn, Sir William Clifton, and other English knights, sustaining the honour of their country against the French, who behaved with the greatest gallantry; and the whole was regarded as one of the most gallant enterprizes which had been fulfilled for some time.

Besides these dangerous amusements, the unsettled and misruled state of things during the feudal times, found a gentle knight anxious to support the oppressed and to put down injustice, and, agreeably to his knightly vow, frequent opportunities to exercise himself in the use of arms. There was everywhere to be found oppressors to be chastised, and evil customs to be abolished, and the knight's occupation not only permitted, but actually bound him to volunteer his services in such cases. We shall err greatly if we suppose that the adventures told in romance, are as fictitious as its magic, its dragons, and its fairies. The machinery was indeed imaginary, or rather like that of Homer, it was grounded on the popular belief of the times. But the turn of incidents resembled, in substance, those which passed almost daily under the eye of the narrator. Even the stupendous feats of prowess displayed by the heroes of these tales, against the most overwhelming odds, were not without parallel in the history of the times. When men fought hand to hand, the desperate exertions of a single champion well mounted and armed in proof, was sometimes sufficient to turn the fate of a disputed day, and the war-cry of a well known knight, struck terror further than his arms. The advantage possessed by such an invulnerable champion over the half-naked infantry of the period, whom he might pursue and cut down at his pleasure, was so great that, in the insurrection of the peasants called the *Jacquerie*, the Earl of Foix and the Captal de Buche, their forces not being nearly as one to ten, hesitated not to charge these disorderly insurgents with their men at arms, and were supposed to have slain nearly seven thousand, following the execution of the fugitives with as little mercy as the peasants had showed during the brief success of their rebellion.

The right which crown-vassals claimed and exercised of imposing exorbitant tolls and taxes within their domains, was often resisted by the knights errant of the day, whose adventures, in fact, approached much nearer to those of Don Quixote than perhaps our readers are aware of. For although the knight of La Mancha was, perhaps, two centuries too late in exercising his office of redresser of wrongs, and although his heated imagination confounded ordinary objects with such as were immediately connected with the exercise of chivalry, yet at no great distance from the date of the inimitable romance of Cervantes, real circumstances occurred, of a nature nearly as romantic as the achievements which Don Quixote aspired to execute. In the more ancient times, the wandering knight could not go far without finding some gentleman oppressed by a powerful neighbour, some captive immured in a feudal dungeon, some orphan deprived of his heritage, some traveller pillaged, some convent or church violated, some lady in need of a champion, or some prince engaged in a war with a powerful adversary, all of which incidents

furnished fit occasion for the exercise of his valour. By degrees, as order became more generally established, and the law of each state began to be strong enough for the protection of the subject, the interference of these self-authorized and self-dependent champions, who besides were, in all probability, neither the most judicious or moderate, supposing them to be equitable, mediators, became a nuisance rather than an assistance to civil society; and undoubtedly this tended to produce those distinctions in the order of knighthood which we are now to notice.

Different Orders of Knighthood.

The most ancient, and originally the sole order of knighthood, was that of the Knight Bachelor. This was the proper degree conferred by one knight on another, without the interference either of prince, noble, or churchman, and its privileges and duties approached nearly to those of the knight-errant. Were it possible for human nature to have acted up to the pitch of merit required by the statutes of chivalry, this order might have proved for a length of time a substitute for imperfect policy,—a remedy against feudal tyranny,—a resource for the weak when oppressed by the strong. Unquestionably, in many individual instances, knights were all that we have described them. But the laws of chivalry, like those of the ascetic orders, while announcing an high tone of virtue and self-denial, unfortunately afforded the strongest temptations to those who professed its vows to abuse the character which they assumed. The degree of knighthood was easily attained, and did not subject the warrior on whom it was granted to any particular tribunal in case of his abusing the powers which it conferred. Thus the knight became, in many instances, a wandering and licentious soldier, carrying from castle to castle, and from court to court, the offer of his mercenary sword, and frequently abusing his character to oppress those whom his oath bound him to protect. The licence and foreign vices imported by those who had returned from the crusades, the poverty also to which noble families were reduced by these fatal expeditions, all aided to throw the quality of knight-bachelor lower in the scale of honour, when unsupported by birth, wealth, or the command of followers.

The poorest knight-bachelor, however, long continued to exercise the privileges of the order. Their title of bachelor (or *Bas Chevalier*, according to the best derivation), marked that they were early held in inferior estimation to those more fortunate knights who had extensive lands and numerous vassals. They either attached themselves to the service of some prince or rich noble, and were supported at their expence, or they led the life of mere adventurers. There were many knights, who, like Sir Gaudwin in the romance of *Partenopex de Blois*, subsisted by passing from one court, camp, and tournament, to another, and contrived, even by various means open to persons of that profession, to maintain, at least for a time, a fair and goodly appearance.

So riding, they o'ertake an errant knight
Well horsed, and large of limb, Sir Gaudwin hight;
He nor of castle nor of land was lord,
Houseless he reap'd the harvest of the sword:
And now, not more on fame than profit bent,
Rode with blythe heart unto the tournament,
For cowardice he held it deadly sin,
And sure his mind and bearing were akin.
The face an index to the soul within,
It seem'd that he, such pomp his train bewray'd,
Had shap'd a goodly fortune by his blade;
His knaves were, point device, in livery dight,
With sumpter-nags, and tents for shelter in the night.

These bachelor knights, as Mr Rose has well described Sir Gaudwin, set their principal store by valour in battle, and perhaps it was the only quality of chivalry which they at all times equally prized and possessed. Their boast was to be the children of war and battle, living in no other atmosphere but what was mingled with the dust of conflict and the hot breath of charging steeds. A "gentle bachelor" is so described in one of the *Fabliaux* translated by Mr Way:

"What gentle bachelor is he,
Sword-begot in fighting field,
Rock'd and cradled in a shield,
Whose infant food a helm did yield."

His resistless gallantry in tournament and battle,—the rapidity with which he traversed land and sea, from England to Switzerland, to be present at each remarkable occasion of action,—with his hardihood in enduring every sort of privation,—and his generosity in rewarding minstrels and heralds,—his life of battle and turmoil,—and his deeds of strength and fame,—are all enumerated. But we hear nothing of his redressing wrongs, or of his protecting the oppressed. The knight-bachelor, according to this picture, was a valiant prize-fighter, and lived by the exercise of his weapons.

In war, the knight-bachelor had an opportunity of maintaining, and even of enriching himself, if fortunate, by the ransom of such prisoners as he happened to make in battle. If, in this way, he accumulated wealth, he frequently employed it in levying followers, whose assistance, with his own, he hired out to such sovereigns as were willing to set a sufficient price on his services. In time of peace, the tournaments afforded, as we have already observed, a certain means of income to these adventurous champions. The horses and arms of the knights who succumbed on such occasions, were forfeited to the victors, and these the wealthy were always willing to reclaim by a payment in money. At some of the achievements in arms, the victors had the right, by the conditions of the encounter, to impose severe terms on the vanquished, besides the usual forfeiture of horse and armour. Sometimes the unsuccessful combatant ransomed himself from imprisonment, or other hard conditions, by a sum of money; a transaction in which the knight-bachelors, such as we have described them, readily engaged. These adventurers used to call the sword which they used in tourneys, their *gagne-pain*, or bread-winner, as itinerant fiddlers of our days denominate their instruments.

Dont i est gaigne-pain nommée
Car par li est gagnies li pains.
Pelerinage du Monde, par Guigneville.

Men of such roving and military habits, subsisting by means so precarious, and lying under little or no restraint from laws, or from the social system, were frequently dangerous and turbulent members of the commonwealth. Every usurper, tyrant, or rebel,

Chivalry.

found knights bachelors to espouse his cause in numbers proportioned to his means of expenditure. They were precisely the "landless resolutes," whom any adventurer of military fame or known enterprise could easily collect

"For food and diet to some enterprise
That hath a stomach in't."

Sometimes knights were found who placed themselves directly in opposition to all law and good order, headed independent bands of depredators, or, to speak plainly, of robbers, seized upon some castle as a place of temporary retreat, and laid waste the country at their pleasure. In the disorderly reigns of Stephen and of King John, many such leaders of banditti were found in England. And France, in the reign of John and his successors, was almost destroyed by them. Many of these leaders were knights, or squires, and almost all pretended that in their lawless licence they only exercised the rights of chivalry, which permitted, and even enjoined, its votaries to make war without any authority but their own, whenever a fair cause of quarrel occurs.

These circumstances brought the profession of knight bachelor into suspicion, as, in other cases, the poverty of those who held the honour exposed it to contempt in their person. The sword did not always reap a good harvest; an enterprise was unfortunate, or a knight was discomfited. In such circumstances, he was obliged to sell his arms and horse, and endure all the scorn which is attached to poverty. In the beautiful lay of Lanval, and in the corresponding tale of Gruelan, the story opens with the picture of the hero reduced to indigence, dunned by his landlord, and exposed to contempt by his beggarly equipment. And when John de Vienne and his French men at arms, returned from Scotland, disgusted with the poverty and ferocity of their allies, without having had any opportunity to become wealthy at the expence of the English, and compelled before their departure to give satisfaction for the insolencies which they committed towards the inhabitants, "divers knights and squires had passage and so returned, some into Flanders, and as wind and weather would drive them, without horse and harness, right poor and feeble, cursing the day that ever they came into Scotland, saying that never man had so hard a voyage." (Berner's *Froissart*, Vol. II. (reprint) p. 32.) The frequent prohibition of tournaments, both by the church and by the more peaceful sovereigns, had also its necessary effect in impoverishing the knights bachelors, to whom, as we have seen, these exhibitions afforded one principal means of subsistence. This is touched upon in one of the French *fabliaux*, as partly the cause of the poverty of a chevalier, whose distresses are thus enumerated:

"Listen gentles, while I tell
How this knight in fortune fell:
Lands nor vineyards had he none,
Justs and war his living won;
Well on horseback could he prance,
Boldly could he break a lance,
Well he knew each warlike use;
But there came a time of truce,
Peaceful was the land around,
Nowhere heard a trumpet sound,
Rust the shield and faulchion hid,
Just and tourney were forbid,
All his means of living gone,
Ermine mantle had he none,
And in pawn had long been laid
Cap and mantle of brocade,
Harness rich and charger stout,
All were eat and drunken out."*

As the circumstances which we have mentioned, tended to bring the order of knight bachelor in many instances into contempt, the great and powerful attempted to entrench themselves within a circle which should be inaccessible to the needy adventurers whom we have described. Hence the institution of Knights Banneret was generally received.

Knight's Banneret.

The distinction betwixt the knight banneret and the knight bachelor was merely in military rank and precedence, and the former may rather be accounted an institution of policy than of chivalry. The bachelor displayed, or was entitled to display, a pennon or forked ensign. The knight banneret had the right of raising a proper *banner*, from which his appellation was derived. He held a middle rank, beneath the barons or great feudatories of the Crown, and above the knights bachelors. The banner from which he took his title was a flag squared at the end, which however in strictness was oblong, and not an exact square on all the sides, which was the proper emblem of a baron. Du Tillet reports, that the Count de Laval challenged Sir Raoul de Couequens' right to raise a square banner, being a banneret, and not a baron, and adds, that he was generally ridiculed for this presumption, and called the knight with the square ensign. The circumstance of the encroachment plainly shows, that the distinction was not absolutely settled, nor have we found the ensign of the bannerets anywhere described except as being generally a square standard. Indeed, it was only the pennon of the knight a little altered; for he who aspired to be a banneret received no higher gradation in chivalry, as attached to his person, and was inducted into his new privileges, merely by the commander in chief, upon the eve of battle, cutting off the swallow-tail or forked termination of the pennon.

In the appendix to Joinville's *Memoirs*, there is an essay on the subject of the bannerets, in which the following account of them is quoted from the ancient book of Ceremonies:

"Comme un bachelier peut lever banniere, et devenir banneret.

"Quant un bachelier a grandement servi et suivy la guerre, et que il a assez terre, et que 'il puisse avoir gentilshommes, ses hommes, et pour accompagner sa banniere, il peut licitement lever banniere, et non autrement. Car nul homme ne doit porter, ne lever banniere en bataille, s'il n'a du moins cinquante hommes d'armes, tous ses hommes et les archiers et arbalestriers qui y appartiennent. Et s'il les a 'il doit à la première battaille, ou il se trouvera, ap-

* See the original in the republication of Barbazan's *Fabliaux*, Vol. III. p. 410.

porter un pennon de ses armes, et doit venir au connestable, ou aux marischaux, ou à celui qui sera lieutenant de l'ost pour le prince, requirer qu'il porte banniere; et s'il lui octroient, doit sommer les heraux pour tesmoignage, et doivent couper la queüe du pennon, et alors le doit porter et lever avant les autres bannieres, au dessoubs des autres barons."

There is this same ceremonial, in a chapter respecting the banneret, in these terms:

"Comme se doit maintenir un banneret en bataille.

"Le banneret doit avoir cinquante lances, et les gens de trait qui y appartiennent: c'est à savoir les xxv. pour lui, et sa banniere garder. Et doit estre sa banniere dessoubs des barons. Et s'il y a autres banniere ils doivent mettre leurs bannieres à l'onneur, chacun selon son endroit, et pareillement tout homme qui porte banniere."

Froissart, always our best and most amusing authority, gives an account of the manner in which the celebrated Sir John Chandos was made banneret by the Black Prince, before the battle of Navarete. The whole scene forms a striking picture of an army of the middle ages moving to battle. Upon the pennons of the knights, penoncels of the squires, and banners of the barons and bannerets, the army formed, or, in modern phrase, dressed its line. The usual word for the attack was, "Advance banners in the name of God and Saint George."

"When the sun was risen, it was a beautiful sight to view these battalions, with their brilliant armour glittering with its beams. In this manner, they nearly approached to each other. The prince, with a few attendants, mounted a small hill, and saw very clearly the enemy marching straight towards them. Upon descending this hill, he extended his line of battle in the plain, and then halted.

"The Spaniards, seeing the English had halted, did the same, in order of battle; then each man tightened his armour, and made ready as for instant combat.

"Sir John Chandos advanced in front of the battalions with his banner uncased in his hand. He presented it to the prince, saying, 'my lord, here is my banner; I present it to you, that I may display it in whatever manner shall be most agreeable to you; for, thanks to God, I have now sufficient lands that will enable me so to do, and maintain the rank which it ought to hold.'

The prince, Don Pedro being present, took the banner in his hands, which was blazoned with a sharp stake gules, on a field argent; after having cut off the tail to make it square, he displayed it, and, returning it to him by the handle, said, 'Sir John, I return you your banner, God give you strength and honour to preserve it.'

"Upon this, Sir John left the prince, went back to his men, with the banner in his hand, 'Gentlemen, behold my banner and yours; you will, therefore, guard it as it becomes you.' His companions, taking the banner, replied with much cheerfulness, that 'if it pleased God and St George, they would defend it well, and act worthily of it, to the utmost of their abilities.'

"The banner was put into the hands of a worthy English squire, called William Allestry, who bore it with honor that day, and loyally acquitted himself in the service. The English and Gascons soon after dismounted on the heath, and assembled very orderly together, each lord under his banner or pennon, in the same battle-array as when they passed the mountains. It was delightful to see and examine these banners and pennons, with the noble army that was under them."

It should not be forgotten, that Sir John Chandos exerted himself so much to maintain his new honour, that, advancing too far among the Spaniards, he was unhorsed, and, having grappled with a warrior of great strength, called Martin Ferrand, he fell undermost, and must have been slain had he not bethought him of his dagger, with which he stabbed his gigantic antagonist. (Johnes's *Froissart*, Vol. I. p. 731.)

A banneret was expected to bring into the field at least thirty men-at-arms, that is, knights or squires mounted, and in complete order, at his own expence. Each man-at-arms, besides his attendants on foot, ought to have a mounted crossbow-man, and a horseman armed with a bow and axe. Therefore, the number of horsemen alone, who assembled under a banner, was at least three hundred, and, including followers on foot, might amount to a thousand men. The banneret might, indeed, have arrayed the same force under a pennon, but his accepting a banner bound him to bring out that number at least. There is no room, however, to believe, that these regulations were very strictly observed.

In the reign of Charles VII., the nobles of France made a remonstrance to the King, setting forth, that their estates were so much wasted by the long and fatal wars with England, that they could no longer support the number of men attached to the dignity of banneret. The companies of men-at-arms which had hitherto been led by knights of that rank, and the distinction between knights bannerets and knights bachelors, was altogether disused from that period.* In England the title survived, but in a different sense. Those who received knighthood in a field of battle, where the royal standard was displayed, were called knights banneret. Thus, King Edward VI. notices in his *Journal*, that, after the battle of Pinkie, "Mr Brian Sadler and Vane were made bannerets."

Companions in Arms.

The distinction of banneret was not the only subdivision of knighthood. The special privileged fraternities, orders, or associations, of knights, using a particular device, or embodied for a particular purpose, require also to be noticed. These might, in part, be founded upon the union which knights were wont to enter to with each other as "companions in arms," than which nothing was esteemed more sacred The partners were united for weal and woe, and no crime was accounted more infamous than to desert or betray a companion at arms. They had the same

* See the works of Pasquier, Du Tillet, Le Gendre, and other French antiquaries.

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friends and the same foes; and, as it was the genius of chivalry to carry every virtuous and noble sentiment to the most fantastic extremity, the most extravagant proofs of fidelity to this engagement were often exacted or bestowed. The beautiful romance of *Ames and Amelien*, in which a knight slays his own child to make a salve with its blood to cure the leprosy of his brother in arms, turns entirely on this extravagant pitch of sentiment.

To this fraternity only two persons could, with propriety, bind themselves. But the various orders, which had in view particular objects of war, or were associated under the authority of particular sovereigns, were also understood to form a bond of alliance and brotherhood amongst themselves.

The great orders of the Templars and Knights-Hospitallers of Saint John of Jerusalem, as well as that of the Teutonic Knights, were military associations, formed, the former for defence of the Holy Land, and the last for conversion (by the edge of the sword of course) of the pagans in the north of Europe. They were managed by commanders or superintendents, and by a grand master, forming a sort of military republic, the individuals of which were understood to have no distinct property or interest from the order in general. But the system and history of these associations will be found under the proper heads. It is here only necessary to notice them as subdivisions of the knighthood, or chivalry of Europe.

Other subdivisions arose from the various associations, also called orders, formed by the different sovereigns of Europe, not only for the natural purpose of drawing around their persons the flower of knighthood, but often with political views of much deeper import. The romances which were the favourite reading of the time, or which, at least, like the servant in the comedy, the nobles "had read to them," and which were on all occasions quoted gravely, as the authentic and authoritative records of chivalry, afforded the most respectable precedents for the formation of such fraternities under the auspices of sovereign princes; the Round Table of King Arthur, and the Paladins of Charlemagne, forming cases strictly in point. Edward III., whose policy was equal to his love of chivalry, failed not to avail himself of these precedents, not only for the exaltation of military honour and exercise of warlike feats, but questionless that he might draw around him, and attach to his person, the most valiant knights from all quarters of Europe. For this purpose, in the year 1344, he proclaimed, as well in Scotland, France, Germany, Hainault, Spain, and other foreign countries, as well as in England, that he designed to revive the Round Table of King Arthur, offering free conduct and courteous reception to all who might be disposed to attend the splendid justs to be held upon that occasion at Windsor Castle. This solemn festival, which Edward proposed to render annual, excited the jealousy of Philip de Valois, king of France, who not only prohibited his subjects to attend the Round Table at Windsor, but proclaimed an opposite Round Table to be held by himself at Paris. In consequence of this interference, the Festival of Edward lost some part of its celebrity, and was diminished in splendour and frequency of attendance. This induced King Edward to establish the memorable Order of the Garter. Twenty-six of the most noble knights of England and Gascony were admitted into this highly honourable association, the well-known motto of which (*Hon y soit qui mal y pense*) seems to apply to the misrepresentations which the French monarch might throw out respecting the Order of the Garter, as he had already done concerning the festival of the Round Table. There was so much dignity, as well as such obvious policy, in selecting from the whole body of chivalry a select number of champions, to form an especial fraternity under the immediate patronage of the sovereign; it held out such a powerful stimulus to courage and exertion to all whose eyes were fixed on so dignified a reward of ambition, that various orders were speedily formed in the different courts of Europe, each having its own peculiar badges, emblems, and statutes. To enumerate these is the task of the herald, not of the historian, who is only called upon to notice their existence and character. The first effect of these institutions on the spirit of chivalry in general, was doubtless favourable, as holding forth to the knighthood an high and honourable prize of emulation. But when every court in Europe, however petty, had its own peculiar order and ceremonial, while the great potentates established several; these dignities became so common, as to throw into the shade the order of Knights Bachelors, the parent and proper degree of chivalry, in comparison to which the others were mere innovations. The last distinction introduced, when the spirit of chivalry was almost totally extinguished, was the degree of Knight Baronet.

Baronet.

The degree of Baronet, or of hereditary knighthood, might have been, with greater propriety, termed an inferior rank of noblesse, than an order of chivalry. Nothing can be more alien from the original idea of chivalry, than that knighthood could be bestowed on an infant, who could not have deserved the honour, or be capable of discharging its duties. But the way had been already opened for this anomaly, by the manner in which the orders of foreign knighthood had been conferred upon children, and infants in nonage. Some of these honours were also held by right of blood; the Dauphin of France, for example, being held to be born a knight of the Holy Ghost, without creation; and men had already long lost sight of the proper use and purpose of knighthood, which was now regarded and valued only as an honorary distinction of rank, that imposed no duties, and required no qualifications, or period of preliminary noviciate. The creation of this new dignity, as is well known, was a device of James I. to fill those coffers which his folly and profusion had emptied; and although the pretext of a Nova Scotia, or of an Ulster settlement, was used as the apology for the creation of the order, yet it was perfectly understood, that the real value given was the payment of a certain sum of money. The cynical Osborne describes this practice of the sale of honours, which, in their origin, were designed as the reward and pledge of chivalrous merit, with satirical emphasis.

"At this time the honour of knighthood, which antiquity reserved sacred, as the cheapest and readi-

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est jewel to present virtue with, was promiscuously laid on any head belonging to the yeomandry (made addle through pride and a contempt of their ancestor's pedigree), that had but a court-friend, or money to purchase the favour of the meanest able to bring him into an outward roome, when the king, the fountaine of honour, came downe, and was uninterrupted by other businesse: in which case, it was then usuall for him to grant a commission for the chamberlaine, or some other lord to do it."

Degradation.

Having noticed the mode in which knighthood was conferred, and the various subdivisions of the order in general, it is proper to notice the mode in which a knight might be degraded from his rank. This forfeiture might take place from crimes either actually committed, or presumed by the law of arms. The list of crimes for which a knight was actually liable to degradation corresponded to his duties. As devotion, the honour due to ladies, valour, truth, and loyalty, were the proper attributes of chivalry,—so heresy, insults or oppression of females, cowardice, falsehood, or treason, caused his degradation. And Heraldry, an art which might be said to bear the shield of Chivalry, assigned to such degraded knights and their descendants peculiar bearings, called in Blazonry abatements, though it may be doubted if these were often worn or displayed.

The most common case of a knight's degradation occurred in the appeal to the judgment of God by the single combat in the lists. In the appeal to this awful criterion, the combatants, whether personally concerned, or appearing as champions, were understood, in martial law, to take on themselves the full risk of all consequences. And, as the defendant, or his champion, in case of being overcome, was subjected to the punishment proper to the crime of which he was accused, so the appellant, if vanquished, was, whether a principal or substitute, condemned to the same doom to which his success would have exposed the accused. Whichever combatant was vanquished, he was liable to the penalty of degradation; and, if he survived the combat, the disgrace to which he was subjected was worse than death. His spurs were cut off, close to his heels, with a cook's cleaver; his arms were bafted and reversed by the common hangman; his belt was cut to pieces, and his sword broken. Even his horse showed his disgrace, the animal's tail being cut off, close to the rump, and thrown on a dunghill. The death-bell tolled, and the funeral service was said, for a knight thus degraded, as for one dead to knightly honour. And, if he fell in the appeal to the judgment of God, the same dishonour was done to his senseless corpse. If alive, he was only rescued from death to be confined in the cloister. Such, at least, were the strict rules of chivalry, though the courtesy of the victor, or the clemency of the prince, might remit them in favourable cases.

Knights might also be degraded without combat, when convicted of a heinous crime. In Stowe's *Chronicle*, we find the following minute account of the degradation of Sir Andrew Harclay, created Earl of Harclay by Edward II., but afterwards accused of traitorous correspondence with Robert the Bruce, and tried before Sir Anthony Lucy.

"He was ledde to the barre as an earle morthily apparelled, with his sword girt about him, horsed, booted, and spurred, and unto whom Sir Anthony spake in this manner. Sir Andrew (quoth he), the King, for thy valiant service, hath done thee great honour, and made thee Earle of Carlile; since which tyme, thou, as a traytor to thy Lord the King, leddest his people, that shoulde have holpe him at the battell of Heighland, awaie by the county of Copland, and through the earledom of Lancaster, by which meanes, our Lorde the King was discomfited there of the Scottes, through thy treason and falsenesse; whereas, if thou haddest come betimes, he hadde had the victorie: and this treason thou committedst for y^e great summe of golde and silver that thou receivedst of James Dowglasse, a Scot, the King's enemy. Our Lord the King will, therefore, that the order of knighthood, by the which thou receivedst all thine honour and worship uppon thy bodie, be brought to nought, and thy state undone, that other knights, of lower degree, may after thee beware, and take example truely to serve.

"Then commanded he to hesne his spurres from his heeles, then to break his sword over his head, which the King had given him to keepe and defend his land therewith, when he made him Earle. After this, he let unclothe him of his furred tabard, and of his hoode, of his coate of armes, and also of his girdle: and when this was done, Sir Anthony sayde unto him, Andrewe (quoth he), now art thou no knight, but a knave; and, for thy treason, the King will that thou shalt be hanged and drawne, and thyne head smitten off from thy bodie, and burned before thee, and thy bodie quartered: and thy head being smitten off, afterwarde to be set upon London bridge, and thy foure quarters shall be sent into foure good townes of England, that all other may beware by thee. And as Anthony Lucy hadde sayde, so was it done in all things, on the last daie of October."

Decay of Chivalry.

III. We are arrived at the third point proposed in our arrangement, the causes, namely, of the decay and extinction of Chivalry.

The spirit of chivalry sunk gradually under a combination of physical and moral causes; the first arising from the change gradually introduced into the art of war, and the last from the equally great alteration produced by time in the habits and modes of thinking in modern Europe. Chivalry began to dawn in the end of the tenth, and beginning of the eleventh century. It blazed forth with high vigour during the Crusades, which indeed may be considered as exploits of national knight-errantry, or general wars, undertaken on the very principles which actuated the conduct of individual knights adventurers. But its most brilliant period was during the wars between France and England, and it was unquestionably in those kingdoms, that the habit of constant and honourable opposition, unembittered by rancour or personal hatred, gave the fairest opportunity for the exercise of the virtues required from him whom Chaucer terms a very perfect gentle knight. Froissart frequently makes allusions to the generosity exercised by the French and English to their prisoners, and contrasts it with the dungeons to which captives taken in war were consigned, both in Spain and Germany. Yet

both these countries, and indeed every kingdom in Europe, partook of the spirit of Chivalry in a greater or less degree; and even the Moors of Spain caught the emulation, and had their orders of knighthood as well as the Christians. But, even during this splendid period, various causes were silently operating the future extinction of the flame, which blazed thus wide and brightly.

An important discovery, the invention of gunpowder had taken place, and was beginning to be used in war, even when chivalry was in its highest glory. It is said Edward III. had field-pieces at the battle of Cressy, and the use of guns is mentioned even earlier. But the force of gunpowder was long known and used, ere it made any material change in the art of war. The long-bow continued to be the favourite, and it would seem the more formidable missile weapon, for well nigh two centuries after guns had been used in war. Still every successive improvement was gradually rendering the invention of fire-arms more perfect, and their use more decisive of the fate of battle. In proportion as they came into general use, the suits of defensive armour began to be less generally worn. It was found, that these cumbrous defences, however efficient against lances, swords, and arrows, afforded no effectual protection against these more forcible missiles. The armour of the knight was gradually curtailed to a light head-piece, a cuirass, and the usual defences of men-at-arms. Complete harness was only worn by generals and persons of high rank, and that rather, it would seem, as a point of dignity than for real utility. The young nobility of France, especially, tired of the unwieldy steel coats in which their ancestors sheathed themselves, and adopted the slender and light armour of the German Reiters or mercenary cavalry. They also discontinued the use of the lance; in both cases, contrary to the injunctions of Henry IV. and the opinion of Sully. At length, the arms of the cavalry were changed almost in every particular from those which were proper to chivalry; and as, in such cases, much depends upon outward show and circumstance, the light armed cavalier, who did not carry the weapons, or practice the exercises of knighthood, laid aside, at the same time, the habits and sentiments peculiar to the order.

Another change of vital importance, arose from the institution of the bands of gens-d'armes, or men-at-arms in France, constituted, as we have observed, expressly as a sort of standing army, to supply the place of bannerets, bachelors, squires, and other militia of early times. It was in the year 1445, that Charles VII. selected from the numerous chivalry of France, fifteen companies of men-at-arms, called Les Compagnies d'Ordonnance, to remain in perpetual pay and subordination, and to enable the sovereign to dispense with the services of the tumultuary forces of chivalry, which, arriving and departing from the host at pleasure, collecting their subsistence by oppressing the country, and engaging in frequent brawls with each other, rather weakened than aided the cause they professed to support. The regulated companies, which were substituted for these desultory bands, were of a more permanent and manageable description. Each company contained an hundred men-at-arms, and each man-at-arms was to be what was termed a *lance garnie*, that is, a mounted spearman, with his proper attendants, being four archers and a varlet, called a *coustillier*. Thus, each company consisted of six hundred horse, and the fifteen bands amounted to fifteen thousand cavalry. The charge of national defence was thus transferred from the chivalry of France, whose bold and desperate valour was sometimes rendered useless by their independent wilfulness and want of discipline, to a sort of regular forces, whose officers (a captain, lieutenant, and an ensign in each company) held command, not in virtue of their knighthood or banner-right, but being direct commissions from the crown, as in modern times. At first, indeed, these bands of regulated gens-d'armes were formed of the same materials as formerly, though acting under a new system. The officers were men of the highest rank, the archers, and even the varlets, were men of honourable birth. When the Emperor Maximilian proposed that the French gens-d'armes should attempt to storm Padua, supported by the German lance-knechts or infantry, he was informed by Bayard, that, if the French men-at-arms were employed, they must be supported by those of the Germans, and not by the lance-knechts, because, in the French companies of ordonnance, every soldier was a gentleman. But, in the reign of Charles IX., we find the change natural to such a new order of things, was in complete operation. The king was content to seek, as qualifications for his men-at-arms, personal bravery, strength, and address in the use of weapons, without respect to rank or birth; and, probably, in many instances, men of inferior birth were preferred to fill up the ranks of these regulated bands. Monluc informs us in his *Commentaries*, that he made his first campaign, as an archer, in the Marechal de Foix's company of gens-d'armes: "A situation much esteemed in these days, when many nobles served in that capacity. At present, the rank is greatly degenerated." The complaints of the old noblesse, says Mezerai, were not without reason. Mean carabineers, they said, valets and lacquies, were recruited in companies, which were put on the same footing with the ancient corps of gens-d'armes, whose officers were all barons of high rank, and almost every man-at-arms a gentleman by birth. These complaints, joined with the charge against Catharine of Medicis, that she had, by the creation of twenty-five new members of the order of Saint Michael, rendered its honours as common as the cockle-shells on the sea-shore, serve to show how early the first rude attempt at establishing a standing and professional army operated to the subversion of the ideas and privileges of chivalry. According to La Noue, it would seem that, in his time, the practice still prevailed of sending youths of good birth to serve as pages in the gens-d'armes; but, from the sort of society with whom they mixed in service of that sort, their natural spirit was rather debased, and rendered vulgar and brutal, than trained to honour and gallantry.

A more fatal cause had, however, been for some

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Civil Wars in France and England.

time operating in England as well as France, for the destruction of the system we are treating of. The wars of York and Lancaster in England, and those of the Huguenots and of the League, were of a nature so bitter and rancorous, as was utterly inconsistent with the courtesy, fair play, and gentleness, proper to chivalry. Where different nations are at strife together, their war may be carried on with a certain degree of moderation. "During the foreign wars between France and Spain, especially in Piedmont," says La Noue, "we might often see a body of spears pass a village, where the peasants only interrupted their village dance to offer them refreshments; and, in a little after, a hostile troop receive, from the unoffending and unoffended inhabitants, the same courtesy. The two bodies would meet and fight gallantly, and the wounded of both parties would be transferred to the same village, lodged in the same places of accommodation, receive the same attention, and rest peaceably on each others good faith till again able to take the field." He contrasts this generosity with the miserable oppression of the civil wars, carried on by murdering, burning, and plundering, friend and foe, armed and unarmed, alleging, all the while, the specious watch-words of God's honour, the King's service, the Catholic religion, the Gospel, our Country. In the end, he justly observes, "the soldiers become ravenous beasts, the country is rendered desert, wealth is wasted, the crimes of the great become a curse to themselves, and God is displeased." The bloody wars of the Rose in England, the execution of prisoners on each side, the fury and animosity which allowed no plea of mercy or courtesy, were scarce less destructive to the finer parts of the spirit of chivalry in England than those of the Huguenots in France.

But the Civil Wars not only operated in debasing the spirit of chivalry, but in exhausting and destroying the particular class of society from which its votaries were drawn. To be of noble birth was not, indeed, absolutely essential to receiving the honour of knighthood, for men of low descent frequently attained it. But it required a distinguished display of personal merit to raise them out of the class where they were born, and the honours of chivalry were, generally speaking, appropriated to those of fair and gentle parentage. The noble families, therefore, were the source from which chivalry drew recruits; and it was upon the nobles that the losses, proscriptions, and forfeitures, of the Civil Wars chiefly fell. We have seen, that, in France, their poverty occasioned their yielding up the privilege of military command to the disposal of the crown. In England it was, fortunately, not so much the crown as the commons who rose on the ruins of the feudal chivalry. But it is well known, that the Civil Wars had so exhausted the English nobility, as to enable Henry VII. to pass his celebrated statutes against those hosts of retainers, which struck, in fact, at the very root of their power. And, thus, Providence, whose ways bring good out of evil, laid the foundation of the future freedom of England in the destruction of what had long been its most constitutional ground of defence, and, in the subjugation of that system of chivalry which, having softened the ferocity of a barbarous age, was now to fall into disuse, as too extravagant for an enlightened one.

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Change of Manners

In fact, it was not merely the changes which had taken place in the constitution of armies and fashion of the fight, nor the degraded and weak state of the nobles, but also, and in a great degree, the more enlightened manners of the times, and the different channels into which enthusiasm and energy were directed, which gradually abolished the sentiments of chivalry. We have seen, that the abstract principles of chivalry were, in the highest degree, virtuous and noble, nay, that they failed by carrying to an absurd, exaggerated, and impracticable point, the honourable duties which they inculcated. Such doctrines, when they fail to excite enthusiasm, become exploded as ridiculous. Men's minds were now awakened to other and more important and complicated exercises of the understanding, and were no longer responsive to the subjects which so deeply interested their ancestors of the middle ages. Sciences of various kinds had been rekindled in the course of the sixteenth century; the arts had been awakened in a style of perfection unknown even to classical ages. Above all, religion had become the interesting study of thousands, and the innovating doctrines of the Reformers, while hailed with ecstacy by their followers, rejected as abominations by the Catholics, and debated fiercely by both parties, involved the nobility of Europe in speculations very different from the *arrets* of the Court of Love, and demanded their active service in fields more bloody than those of tilt and tournament. When the historians or disputants on either side allude to the maxims of chivalry, it is in terms of censure and ridicule. Yet, if we judge by the most distinguished authorities on either side, the Reformers rejected as sinful what the Catholics were contented to brand as absurd. It is with no small advantage to the Huguenots,—to that distinguished party which produced Sully, D'Aubigné, Coligni, Duplessis-Mornay, and La Noue, that we contrast the moral severity with which they pass censure on the books of chivalry with the licentious flippancy of Brantome, who ridicules the same works, on account of the very virtues which they inculcate. From the books of *Amadis de Gaul*, refining, as he informs us, upon the ancient vanities of Perceforest, Tristan, Giron, &c., La Noue contends the age in which he lived derived the recommendation and practice of incontinence, of the poison of revenge, of neglect of sober and rational duty, desperate blood-thirstiness, under disguise of search after honour, and confusion of public order. "They are the instructions," he says, "of Apollyon, who, being a murtherer from the beginning, delighteth wholly in promoting murther." "Of the tournaments," he observes, "that such spectacles, rendering habitual the sight of blows and blood, had made the court of France pitiless and cruel." "Let those," he exclaims, "who desire to feed their eyes with blood, imitate the manner of England, where they exercise their cruelty on brute beasts, bringing in bulls and bears to fight with dogs,

a practice beyond comparison far more lawful than the justs of chivalry." *

It is curious to contrast the opinions of La Noue, a stern and moral reformer, and a skilful and brave soldier as France ever produced, although condemning all war that did not spring out of absolute necessity; with those of Brantome, a licentious courtier, who mixed the popish superstitions, which stood him instead of religion, with a leaven of infidelity and blasphemy. From the opinions he has expressed, and from what he has too faithfully handed down as the manners of his court and age, it is plain that all which was valuable in the spirit of chivalry had been long renounced by the French noblesse. To mark this declension, it is only necessary to run over the various requisites already pointed out as necessary to form the chivalrous character, and contrast them with the opinions held in the end of the sixteenth century, in the court of the descendants of Saint Louis.

The spirit of devotion which the rules of chivalry inculcated, was so openly disavowed, that it was assigned as a reason for preferring the character of Sir Tristram to that of Sir Lancelot, that the former is described in romance as relying, like Mezentius, upon his own arm alone, whereas Lancelot, on engaging in fight, never failed to commend himself to God and the saints, which, in the more modern opinions of the gallants of France, argued a want of confidence in his own strength and valour.

The devotion with which the ancient knights worshipped the fair sex, was held as old-fashioned and absurd as that which they paid to heaven. The honours paid to chastity and purity in the German forests, and transferred as a sacred point of duty to the sons of chivalry, was as little to be found in the court of France, according to Brantome, as the chastity and purity to which it was due. The gross and coarse sensuality which we have seen engrafted upon professions of Platonic sentiment, became finally so predominant, as altogether to discard all marks of sentimental attachment; and from the time of Catharine of Medicis, who trained her maids of honour as courtezans, the manners of the court of France seem to have been inferior in decency to those of a well regulated bagnio. The sort of respect which these ladies were deemed entitled to, may be conjectured from an anecdote given by Lord Herbert of Cherbury, whose own character was formed upon the chivalrous model which was now become obsolete. As he stood in the trenches before a besieged place, along with Balagny, a celebrated duellist of the period, between whom and Lord Herbert some altercation had formerly occurred, the Frenchman, in a bravade, jumped over the entrenchment, and, daring Herbert to follow him, ran towards the besieged place, in the face of a fire of grape and musquetry. Finding that Herbert outran him, and seemed to have no intention of turning back, Balagny was forced to set the example of retreating. Lord Herbert then invited him to an encounter upon the old chivalrous point, which had the fairer and more virtuous mistress; to which proposition Balagny replied by a jest so coarse, as made the Englishman retort, that he spoke like a mean debauchee, not like a cavalier and man of honour. As Balagny was one of the most fashionable gallants of his time, and, as the story shows, ready for the most hair-brained achievements, his declining combat upon the ground of quarrel chosen by Lord Herbert, is a proof how little the former love of chivalry accorded with the gallantry of these later days.

Bravery, the indispensable requisite of the *preux chevalier*, continued, indeed, to be held in the same estimation as formerly; and the history of the age gave the most brilliant as well as the most desperate examples of it, both in public war and private encounter. But courage was no longer tempered with the good faith and courtesy,—*La bonta dei gli cavalieri antichi*, so celebrated by Ariosto. There no longer existed those generous knights, that one day bound the wounds of a generous enemy, guided him to a place of refuge, and defended him on the journey, and which, on the next, hesitated not to commit itself in turn to the power of a mortal foe, without fear that he would break the faithful word he had pawned for the safety of his enemy. If such examples occur in the civil wars of France, they were dictated by the generosity of individuals who rose above the vices of their age, and were not demanded, as matters of right, from all who desired to stand well in public opinion. The intercourse with Italy, so fatal to France in many respects, failed not to imbue her nobility with the politics of Machiavel,—the coarse licentiousness of Aretin,—and the barbarous spirit of revenge, which held it wise to seek its gratification, not in fair encounter, but *per ogni modo*, in what manner soever it could be obtained. Duels, when they took place, were no longer fought in the lists, or in presence of judges of the field, but in lonely and sequestered places. Inequality of arms was not regarded, however great the superiority on one side. "Thou hast both a sword and dagger," said Quelus to Antragues, as they were about to fight, "and I have only a sword."—"The more thy folly," was the answer, "to leave thy dagger at home. We came to fight, not to adjust weapons." The duel accordingly went forward, and Quelus was slain, his left hand (in which he should have had his dagger) being shockingly cut in attempting to parry his antagonist's blows without that weapon. The challenged person having a right to choose his weapons, often endeavoured to devise such as should give him a decidedly unfair advantage. Brantome records with applause the ingenuity of a little man, who, being challenged by a tall Gascon, made choice of a gorget so constructed, that his gigantic adversary could not stoop his neck, so as to aim his blows right. Another had two swords forged of a temper so extremely brittle, that, unless used with particular caution, and in a manner to which he daily exercised

* *Discourses, Political and Military*, translated out of the French of La Noue, 1587.

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himself, the blade must necessarily fly in pieces. Both these ingenious persons killed their man with very little risk or trouble, and no less applause, it would seem, than if they had fought without fraud and covine. The seconds usually engaged, and when one of the combatants was slain, his antagonist did not hesitate to assist his comrade in oppressing by odds him who remained. The *little French Lawyer* of Fletcher turns entirely on this incident. By a yet more direct mode of murder, a man challenged to a duel was not always sure that his enemy was not to assassinate him by the assistance of ruffians at the place of rendezvous, of which Brantome gives several instances without much censure. The plighted word of an antagonist by no means insured against treachery to the party to whom it was given. De Rosne, a gentleman well skilled in the practice and discipline of the wars, receiving a challenge from De Fargy, through the medium of a young man, who offered to pledge his word and faith for the fair conduct of his principal—made an answer which Brantome seems to approve as prudential. "I should be unwilling," he replied, "to trust my life upon a pledge on which I would not lend twenty crowns." In many cases no ceremony was used, but the nobles assassinated each other without scruple or hesitation. Brantome gives several stories of the Baron des Vitaux, and terms his detestable murders bold and brave revenges. But it would be endless to quote examples. It is enough to call to the reader's recollection the bloody secret of the massacre of St Bartholemew, which was kept by such a number of the Catholic noblemen for two years, at the expence of false treaties, promises, and perjuries innumerable, and the execution which followed on naked, unarmed, and unsuspecting men, in which so many gallants lent their willing swords.

In England, the free tone of the government, and the advantage of equal laws, administered without respect of persons, checked similar enormities, which however do not appear to have been thought, in all cases, inconsistent with the point of honour, which, if not, as in France, totally depraved from the ancient practices of chivalry, might probably have soon become so. Sir John Ayres did not hesitate to attack Lord Herbert with the assistance of his servants; and the outrage upon the person of Sir John Coventry, which gave rise to the Coventry act against cutting and maiming, evinced the same spirit of degenerate and blood-thirsty revenge. Lord Sanquhar having lost an eye in a trial of skill with a master of defence, conceived that his honour required that he should cause the poor man to be assassinated by ruffians in his own school. But as this base action met its just reward at the gallows, the spirit of Italian revenge was probably effectually checked by such a marked example. At the gallows, the unfortunate nobleman expressed his detestation for the crime, which he then saw in all its enormity. Before his trial, he said, the devil had so blinded his understanding, that he could not understand that he had done amiss, or otherwise than befitting a man of high rank and quality, having been trained up to the court, and living the life of a soldier, which sort of men, he said, stood more on a point of honour than religion. The feelings of chivalry must have been indeed degraded, when so base an assassination was accounted a point of honour. In Scotland, the manners of which country, as is well observed by Robertson, strongly resembled those of France, the number of foul murthers during the sixteenth century was almost incredible, and indeed assassination might be termed the most general vice of the sixteenth century.

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From these circumstances, the total decay of chivalrous principle is sufficiently evident. As the progress of knowledge advanced, men learned to despise its fantastic refinements; the really enlightened, as belonging to a system inapplicable to the modern state of the world; the licentious, fierce, and subtile, as throwing the barriers of affected punctilio, betwixt them and the safe, ready, and unceremonious gratification of their lust or their vengeance.

The system, as we have seen, had its peculiar advantages during the middle ages. Its duties were not, and indeed could not always be performed in perfection, but they had a strong influence on public opinion; and we cannot doubt that its institutions, virtuous as they were in principle, and honourable and generous in their ends, must have done much good and prevented much evil. We can now only look back on it as a beautiful and fantastic piece of frostwork, which has dissolved in the beams of the sun! But though we look in vain for the pillars, the vaults, the cornices, and the fretted ornaments of the transitory fabric, we cannot but be sensible that its dissolution has left on the soil valuable tokens of its former existence. We do not mean, nor is it necessary to trace, the slight shades of chivalry, which are yet received in the law of England. An appeal to combat in a case of treason, was adjudged in the celebrated case of Ramsay and Lord Reay, in the time of Charles I. An appeal of murder seems to have been admitted as legal within the last year, and is perhaps still under decision. But it is not in such issues, rare as they must be, that we ought to trace the consequences of chivalry. We have already shown, that its effects are rather to be sought in the general feeling of respect to the female sex; in the rules of forbearance and decorum in society; in the duties of speaking truth and observing courtesy; and in the general conviction and assurance, that, as no man can encroach upon the property of another without accounting to the laws, so none can infringe on his personal honour, be the difference of rank what it may, without subjecting himself to personal responsibility. It will be readily believed that, in noticing the existence of duelling as a relic of chivalry, we do not mean to discuss the propriety of the custom. It is our happiness that the excesses to which this spirit is liable, are checked by the laws which wisely discountenance the practice; for although the severity of the laws sometimes give way to the force of public opinion, they still remain an effectual restraint, in every case where the circumstances argue either wanton provocation or unfair advantage. It is to be hoped that, as the custom of appealing to this Gothic mode of settling disputes is gradually falling into disuse, our successors may enjoy the benefit of the general urbanity, decency, and courtesy which it has introduced into the manners of Europe, without having recourse to a remedy, not easily reconciled to law or to Christianity. (N. N.)

CHROMATICS.

CHROMATICS. The gradual progress of scientific investigation has continued to add, from year to year, a multitude of new discoveries to our knowledge of experimental and physical optics: and no department of this subject has received additions, so diversified and so important, as those which relate to the phenomena of colours, which have been displayed, with a thousand brilliant and unexpected transformations, under circumstances that, in former times, could never have been suspected of exhibiting any thing resembling them. The successive experiments and calculations of Dr Thomas Young (1801), Dr Wollaston (1802), Mr Malus (1810), Mr Arago, Mr Biot, Dr Brewster, Dr Seebeck, and Mr Fresnel, have all contributed very essentially to the extension and illustration of this interesting branch of science. But notwithstanding all that has hitherto been done, it appears to be utterly impracticable, in the present state of our knowledge, to obtain a satisfactory explanation of all the phenomena of optics, considered as mechanical operations, upon any hypothesis respecting the nature of light that has hitherto been advanced: It will therefore be desirable to consider the facts which have been discovered, with as little reference as possible to any general theory; at the same time, it will be absolutely necessary, as a temporary expedient, to borrow from the undulatory system Dr Young's law of the interference of light, as affording the only practicable mode of connecting an immense variety of facts with each other, and of enabling the memory to retain them: and this adoption will be the more unexceptionable, as many of the most strenuous advocates for the projectile theory have been disposed, especially since the experiments of Mr Arago and Mr Fresnel, to admit the truth of the results of all the calculations, in which this law has been employed. The details of its application to particular cases, together with an examination of the phenomena of polarisation and of oblique refraction, will occupy the principal part of this article; but it will also be necessary to premise an account of the few cases of the exhibition of colours which appear to be independent of its operation.

SECTION I.—*Of the Separation of Colours by Refraction.*

The separation of white light into different colours, as its component parts, by refraction, though firmly established as an optical fact by Newton, had been in general somewhat negligently examined as to its details, until Dr Wollaston pointed out the inaccuracy of the common subdivision of the colours of the prismatic spectrum into seven different species. There is little reason to doubt, that white light consists of an infinite number of rays, varying gradually among each other, without any marked distinctions, and continued on the one hand into the dark chemical rays, and on the other into the rays of invisible heat; and that all these varieties are separable from each other by refraction, and preserve always a distinct and constant refrangibility. The species of homogeneous light, however, distinguishable from each other by the eye, are only five; red, yellow, green, blue, and violet; which are uniform in their appearance, and well defined in their limits, whenever a perfect spectrum is correctly exhibited; whether obtained by interposing a prism, between the eye and a small or rather narrow bright object, or between a lens and the image of such an object formed in its focus: while, in the common method of admitting a beam of the sun's light through a prism, without either employing a lens, or previously limiting the angular extent of the beam, it is obvious that there must be a double source of the mixture of colours; and hence has arisen the Newtonian division of the spectrum into seven parts, which were somewhat fancifully compared, with respect to their extent, to the intervals of the minor diatonic scale in music; although it has been shown by Dr Blair, and still more fully by Dr Brewster, that their proportions are liable to very great variations, according to the nature of the refracting substances employed.

Dr Brewster has remarked, that as, according to the fundamental law of refraction, a prism with a large angle must occasion a dispersion of the several colours somewhat greater than two smaller prisms of the same substance, having together an equal mean refractive power; so also the dispersion of the most refrangible or violet rays amongst themselves will be always somewhat greater in a prism with a larger angle, than in two smaller prisms having an equal mean dispersive power; hence the green and blue will be less removed from the red towards the violet by the single prism, the refraction of the green remaining in defect when compared with the mean of the whole; so that if the two prisms be employed to correct the mean dispersion of the single one, and the extreme rays of the spectrum be brought to a perfect coincidence, the refraction of the green by these prisms being comparatively in excess, the green rays will be found on the side towards which their refraction tends to carry them; and the two extreme portions of red and violet will be left together, forming a crimson, on the side towards which the refraction of the larger prism is directed. It is obvious also that if, instead of the two smaller prisms, a single one of an equal angle, but of twice the dispersive power, were substituted, the joint effect would be nearly the same: Dr Brewster has however observed, that in almost all such combinations of different substances, the green is on the side towards which the refraction of the larger prism is directed; so that the original proportion of the space occupied

by the different rays in the spectrum must be different for different substances. Dr Brewster has found that the violet is the most dispersed by oil of cassia and by sulphur, and least by sulphuric acid and by water: the distribution, afforded by these substances, appearing to vary from 2 parts of red, 3 green, 4 blue, and 3 violet, to about 4 red, 3 green, 3 blue, and 2 violet: while the yellow is always confined to a narrow line.

The immediate effects of the combinations of the primitive colours on the sense of sight afford an illustration of some of the physiological characters of sensation in general. It is well known that a mixture of red and green light produces a simple sensation, perfectly identical with that which belongs to the minute portion of yellow light originally found in the spectrum: and that a mixture of green and violet makes a perfect blue. The blue colour of the flame of spirit of wine, for example, is derived entirely from a mixture of green and violet rays; while the blue light of the lower part of the flame of a candle is shown by the prism to consist of five different portions, belonging to different parts of the spectrum, nearly resembling those which would be distinguished, if we looked through a prism at a small portion of a transparent plate, of a certain minute thickness. It is obvious, therefore, that the eye has no immediate power of analysing such light; and if we seek for the simplest arrangement, which would enable it to receive and discriminate the impressions of the different parts of the spectrum, we may suppose three distinct sensations only to be excited by the rays of the three principal pure colours, falling on any given point of the retina, the red, the green, and the violet; while the rays occupying the intermediate spaces are capable of producing mixed sensations, the yellow those which belong to the red and green, and the blue those which belong to the green and violet; the mixed excitement producing in this case, as well as in that of mixed light, a simple idea only: although it must be observed, that no homogeneous light can extend its action so far as to excite at once the sensations of the fibres belonging to the red and the violet: so that every crimson must necessarily be a compound colour. A mixture of red and blue light exhibits an effect which appears unintelligible, upon the supposition that a compound light ought to produce a colour intermediate between those of its constituent parts; but this difficulty will vanish, if we assume that the blue of the spectrum contains a greater proportion of violet than of green; so that the green is neutralised into a white by a mixture with the red and part of the violet, and the remaining violet gives its character to the whole, either alone, or with a mixture of red, according to the proportions employed.

When we look through a prism at a luminous object of considerable extent, surrounded by a dark space, the spectra belonging to the several parts of the object are mixed with each other, so as to produce a light perfectly white, except towards the ends of the object, where the extreme parts project beyond each other. At the red end of the spectrum, the whole of the red belonging to the extreme point retains its place unaltered, and the green and blue become a greenish yellow, nearly uniform in its appearance, throughout the space which belongs to them, while the place of the violet is scarcely distinguishable from the neighbouring white light; but at the opposite end, the violet retains its place and appearance, and the remainder of the length of the spectrum becomes of a green, inclining more or less to blue, and continuing to be very distinctly visible throughout the extent of the simple spectrum, the place of the red included: so that the illuminating power of the red end of the spectrum must be incomparably greater than that of the violet end: as may also be inferred by a direct comparison of the distinctness of objects viewed in these different lights. The portion of light totally reflected at the internal surface of a dense medium, on account of the obliquity of its incidence, is bounded by a fringe or bow resembling the red end of the luminous object viewed through a prism; and the transmitted portion is bounded by the violet and blue fringe: but it requires some caution, in observing these colours, to avoid the optical deception, which causes the neighbouring space to appear of the complementary colour, especially when the eye is turned towards it immediately after having received the impression of the colours actually exhibited.

Section II.—*Of the Colours of Halos and Parhelia.*

The immediate effect of the different refrangibility of light, in the production of colours, is sometimes spontaneously exhibited, in the atmospherical phenomena of halos and parhelia, or paraselenes, attending the sun or moon; the edge nearest to the luminary being generally reddish, and the remoter parts more or less green and blue, although without any well marked separation of the different tints. These appearances had been long ago referred by Mariotte to the refraction of the prismatic crystals of snow, floating in the atmosphere, and descending through it, in all possible positions, but more especially in a vertical or horizontal direction, on account of the effect of gravity, combined with that of the resistance of the air; and sometimes, perhaps, from their connexion with other crystals, making angles of 60° with either of these positions. This theory, however simple and satisfactory, had been very unaccountably neglected for more than a century, and even superseded by the awkward and unsupported conjectures of Huygens, respecting the existence of spherical or cylindrical particles of hail, including opaque nodules, related to them in a certain constant ratio; or by the equally inadmissible calculation of Newton, which assigns a partial maximum to the density of the light simply refracted through a spherical drop of water, when the deviation is about 26°; and it is only a few years since, that the doctrine of Mariotte was revived and extended by Dr Young, and approved by Mr Cavendish and Mr Arago.

In some of the highest northern latitudes, these appearances of halos and parhelia are almost constant; and in warmer countries they are confined to the light clouds which occupy the higher and colder regions of the atmosphere. The halos are broad

circles, with their interior margin tolerably well defined, and about the distance of 22 and 46 degrees from the sun or moon, but less distinctly terminated externally. Now the angle of 22^0 exactly corresponds to the deviation produced by a prism of ice, with a refracting angle of 60^0, when it becomes a minimum from the equality of the angles of incidence and emergence; and in other positions of the prism, the deviation increases very slowly till it becomes a few degrees greater: hence the breadth of the circles of each colour being considerable, the colours must fall principally on each other, and become very indistinctly separated. The external circle may be referred to the effect of two such refractions in succession: Mr Cavendish seems to have thought the angle somewhat too great to be derived from this source; and he suggested that it might depend on a single refraction by the rectangular terminations of the crystals: but it does not appear that such terminations are very commonly observable; and it may easily be shown, that the greatest intensity of the light of a halo, formed by two refractions, must be at more than twice the distance of the edge of the inner halo, derived from one only.

These halos are commonly accompanied by a white horizontal circle passing through the sun, derived from the reflection of the vertical faces of the crystals, which are scattered equally throughout all possible azimuths. There are also generally coloured parhelia on each side, depending on the refraction of these vertical prisms; they are commonly a little without the halos, because the deviation of the light passing obliquely through these crystals is somewhat greater than that of the light transmitted by the crystals which have their axes perpendicular to the plane of incidence and refraction. For a similar reason, the light passing through the crystals situated horizontally, in various azimuths, is variously modified, so as to produce the appearance of inverted arches, touching the halos at their highest points, and sometimes expanding in the form of a pair of wings, with a point of contrary flexure on each side.

The anthelia seem to be referable to two refractions and an intermediate reflection, within the same crystal, causing a deviation of about $120 + 22 = 142^0$; and sometimes with two intermediate reflections, producing an angle of $60 + 22 = 82^0$ only. It is not, however, very easy to assign a reason for the appearance of an anthelion exactly opposite to the sun, which is said to have been sometimes seen in the horizontal circle: but it has been delineated with the accompaniment of an oblique cross, and of other unusual appearances, which must have been derived from some extraordinary forms of the compound crystals of snow, existing, at the time of the observation, in the atmosphere.

Section III.—*Of the Colours of the Rainbow.*

The general nature of the primary rainbow was cursorily explained by De Dominis; but Descartes first applied the true law of refraction, which had lately been discovered, to the determination of the angular magnitude both of this and of the secondary rainbow; although no sufficient reason could be assigned for the appearance of colours in either of them, until Newton ascertained the different refrangibilities of the different kind of rays: but as soon as this discovery was established, the method of fluxions at once enabled him to determine precisely the limit, at which the broad expanse of light, belonging to each colour, must necessarily terminate in an edge of greater brilliancy; the bright edges of the different colours projecting gradually beyond each other, so as to form a spectrum somewhat mixed, but still approaching to the common appearance of a spectrum obtained by the refraction of a prism: and in fact, the angular distances of the exterior termination of the primary rainbow and of the interior of the secondary, from the sun, are found to agree very accurately with the calculation of the extreme deviations of the red rays reflected once and twice respectively within the spherical drops of rain; although the whole breadth of the coloured appearances is liable to variations dependent on the magnitude of the drops, and belonging to the phenomena of supernumerary rainbows, to be described hereafter.

The light reflected from very small portions of water appears to be incapable of producing a regular rainbow; thus we scarcely ever see a rainbow in a cloud, unless it has united its drops, so that they begin to descend in the form of rain. Dr Smith has observed this circumstance, and has attributed it to a tendency of the bright edge of the expanse of light to lose its intensity, by being gradually dissipated into the neighbouring dark space: a tendency which he would probably have been much at a loss to explain from any of the received doctrines of optics; but which bears some analogy to the effects more commonly observed in beams of light admitted into dark spaces, and sometimes designated by the term diffraction.

Section IV.—*Of Periodical Colours in general.*

By far the greater part of the phenomena of colours, except their separation by simple refraction, are referable to the description of periodical or recurrent colours: being characterized by an alternation, which is generally repeated, where the observation is sufficiently extensive, several times in succession, while the circumstances, on which they depend, are varied uniformly and by slow degrees. The number of these alternations, when light perfectly homogeneous is employed, appears to be continued without any discoverable limit, although it is always smaller, for any given change of circumstances, when the least refrangible or red light is employed, than when the observation is made on the most refrangible or violet; so that mixed or white light always produces a combination of alternations arranged according to a series of different intervals, which are at first more or less distinct, but by degrees are so mixed with each other, as again to be lost in the general effect of white light. In all these cases, the appearances may be reduced to calculation by means of the general law of the interference of two portions of light, with its appropriate modifications and corrections.

A. *The aw is, that when two equal portions of light, in circumstances exactly similar, have been separated and coincide again, in nearly the same direction, they will either cooperate, or destroy each other, accordingly as the difference of the times, occupied in their separate paths, is an even or an odd multiple of a certain half interval, which is different for the different colours, but constant for the same kind of light.*

B. *In the application of this law to different mediums, the velocity must be supposed to be inversely as the refractive density.*

C. *In reflections at the surface of a rarer medium, and of some metals, in all very oblique reflections, in diffraction, and in some extraordinary refractions, a half interval appears to be lost.*

D. *It is said that, according to some late observations of Mr Arago, two portions of light, polarised in transverse directions, do not interfere with each other.*

E. *The principal intervals in air are for the*

Extreme Red	-	$.0000266 = \frac{1}{37640}$
Yellow	-	$.0000235 = \frac{1}{42530}$
Green	-	$.0000211 = \frac{1}{47460}$
Blue	-	$.0000189 = \frac{1}{52910}$
Extreme Violet		$.0000167 = \frac{1}{59750}$
Mean, or White		$.0000225 = \frac{1}{44440}$ *inch.*

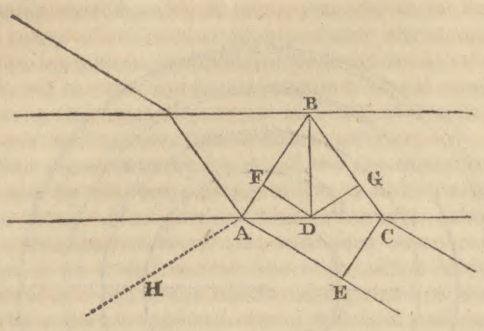
Section V.—*Of the Colours of thin Plates.*

The colours exhibited by very thin plates of transparent or semitransparent substances have been well known to optical philosophers, from the time that they were first noticed by Boyle, and more particularly examined by Hooke and Newton. They may be readily observed, by pressing together any two clean pieces of common plate-glass, which have always sufficient convexities and concavities to exhibit them, touching each other in some points, and leaving elsewhere a thin plate of air between them; or still more conveniently, by selecting from the planoconvex lenses, kept by the opticians, such as have their flatter sides very slightly convex, and are consequently calculated to throw the spaces of equal thickness, and the colours dependent on them, into the form of rings. The colours are most distinct when they are formed in the light reflected from the two surfaces in contact, especially when care is taken to exclude the foreign light, reflected by the surfaces not concerned in their production: and in this case they begin from a central dark spot, immediately surrounded by a bright light, and then by rings more distinctly coloured; while the colours, exhibited in light transmitted through the glasses, begin from a bright spot in the centre, surrounded by a dark ring; being always exactly complementary to the colours seen by reflection; to which they are also, as Mr Arago has demonstrated, either exactly or very nearly equal in intensity; although they have generally been supposed to be much less vivid, on account of the diminution of their effect on the eye by their mixture with the whole of the beam of light which affords them. But if we employ, for the observation, two flattish pieces of glass, held in such a position as to transmit the light received from one part, and to reflect an image of another part, of an object equally illuminated throughout its extent, the two series of colours will destroy each other, and the whole appearance of rings will vanish; when, on the contrary, the illumination of the object varies materially, the rings will reappear in one or the other of their forms, according to the different intensities of the lights received from its different parts: so that, as Mr Arago has ingeniously suggested, this test might be employed to answer the purpose of a photometer, for ascertaining the equality of the lights of two distant objects.

If any thin plate, affording colours, be inclined to the direction of the light passing through it, the appearance of the colours will be changed either precisely or very nearly in the same manner as if the thickness were reduced, in the ratio of the radius to the cosine of the inclination within the plate; at least, if this proportion is not perfectly accurate, the deviations from it, in the experiments of Newton, are manifestly within the limits of the unavoidable errors of observation.

We are indebted to Mr Arago for the important fact, that the colours, observed in transmitted light, are distinguished by a polarisation opposite or transverse to that which is appropriate to transmitted light in general, and possessing the ordinary character of the polarisation produced by partial reflection. It is in light thus reflected that we must seek for one of the two portions which are to be combined according to the laws of interference, in the case of the colours seen by transmission, and for both in the case of reflection. The light transmitted simply through the plate will be followed by a portion which has been reflected back from the second surface to the first, and forwards again from the first to the second, and the difference of the times, occupied in these different paths, will obviously be proportional to the thickness of the plate, and also, according to the modification (B) of the law, to its refractive density: so that the number of alternations of any given colour, between the central spot of the rings and any given point, will be as the thickness of the plate at that point; and the numbers for different colours will be inversely as the magnitudes of the appropriate intervals; the plate appearing light, when illuminated by a homogeneous colour only, where the thickness corresponds to any exact multiple of the interval, and dark at the intermediate points; and this proportion is found to agree perfectly with experiment. The two reflections within the plate, being always of the same kind, will either not require any correction on account of their nature (C), or will together add a whole interval to the length of the path, an alteration which makes no change in the appearances.

When the incidence is oblique, the actual length of the two passages of the reflected ray across the plate, AB, BC, is as twice the secant of the angle of refraction ABD, and its advance upon the surface, AC, as twice the tangent: and this advance, reduced to the direction of the transmitted ray AE without the plate, must be subtracted from the retardation within the plate; the reduction being in the proportion of the radius to the sine of the angle of incidence ACE, for which if we substitute that of the radius to the sine of the angle of refraction ADF



or CDG, we shall have the deduction required to be made from the length of the path within the plate, since the velocities vary directly as these sines; and by this deduction the secants, AB, BC, will be reduced to the cosines BF, BG: so that the true retardation will always be proportional to the cosine of refraction.

The same demonstration is applicable to the difference of the paths of the two portions of light reflected once only, from the upper and lower surfaces of the plates respectively, supposing A, the point of emergence of the transmitted ray, to become the point of incidence of a new reflected ray HA. Hence it might be expected that all the phenomena of colours should be the same as in the case of transmitted light; and this really appears to happen when the observation is made on a plate of air contained between a transparent substance and a polished surface of gold or silver; or on a plate of a refractive density intermediate between the densities of the neighbouring substances, as in the instance of a thin coat of smoke or of an oxid, adhering to any polished metallic surface, which is at first of a yellowish white, and as it becomes thicker, changes to a yellow and an orange colour: but in more common cases there is a loss of half an interval in one of the two reflections only, so that the thicknesses affording a perfect coincidence, for any species of colour, are always intermediate between the thicknesses affording the same colour by transmission; and hence the tints of the two series of rings are always complementary to each other, the series seen by reflection always beginning from a dark central spot, when they are exhibited by any detached transparent substance, as a soap bubble, a thin film of glass, or of talc, or by a plate of air contained between two plates of glass, or between a plate of glass and a piece of polished steel.

There is a peculiarity in the surface of silver and gold, and perhaps of some other metals, that besides the regular reflection at an angle equal to that of incidence, a considerable quantity of light is dispersed irregularly; and this light, as Mr Arago has observed, is polarised in a direction transverse to that of the usual polarisation by reflection; there is also in the irregular reflection no loss of a half interval; so that it exhibits, with a piece of glass, a series of rings resembling those which are produced by polished steel, except that their dimensions are not varied exactly in the same proportion by the obliquity of the incidence, because the light which forms them is not required to pass towards the metal in an angle exactly equal to that which it makes upon its return after reflection; and there will probably be considerable irregularities in the interval of retardation, according to the mode of performing the experiment; although in general the irregular dispersion or diffraction from the glass is too weak to afford colours easily observable, when the position of the plate differs considerably from that in which the light is regularly reflected. If a portion of polarised light is incapable of interfering with another portion polarised in a transverse direction, these rings ought to disappear when the angle of incidence on the plate of glass is about 55°, since in this case the light reflected by it is completely polarised in the plane of incidence: and this disappearance seems actually to have been observed in some of Mr Arago's experiments, though in others, where the metallic surface was less highly polished, the polarisation of the dispersed light may have been less complete, and the rings may still have been visible at this angle. (*Mémoires d'Arcueil*, Vol. III. p. 354, 359.)

Section VI.—*Of the Colours of Double Plates.*

When light is transmitted in succession through two plates, differing but little in thickness, they exhibit an appearance of colour similar to that which would be produced by a single plate equal in thickness to their difference; and this appearance is wholly independent of the distance of the plates from each other. It was first noticed by Mr Nicholson, in the glasses employed for the sights of sextants, and is attributed by Dr Young to "the rays twice reflected within the first glass only, interfering with the rays twice reflected in the second only:" in some circumstances, however, the light returning from the second glass to the first, and again reflected by it, may cooperate in the effect; the interval of retardation being the same in both cases. Mr Knox has more lately described some very striking appearances of colours, obtained in this way, by the combination of two pairs of lenses, each exhibiting their appropriate rings when viewed separately, and affording together a third series of rings of larger dimensions, when the two former are unequal in magnitude, and of straight bands when they are equal. It is in fact easily demonstrable, that in order that the thicknesses of the plates of air, contained between two unequal pairs of lenses, may be equal, the distances from the centres of contact must be in a constant proportion; and it is well known that all the points, from which the lines drawn to two given points are in a constant proportion, will be found in the circumference of a circle, the diameter of which is a third proportional to the difference and sum of the segments of the given distance of the points: so that the colours, depending on this difference, instead of beginning as usual from a white central spot, will begin from a white ring, and will be arranged in concentric rings on each side of it, precisely in the same order as when they form concentric rings round an actual point of contact: and when the curvatures of the two pairs of lenses are equal, the diameter of the circle becoming infinite, it will obviously be converted into a right line.

Dr Brewster has observed a series of similar phenomena, produced by two plates, of equal thickness,

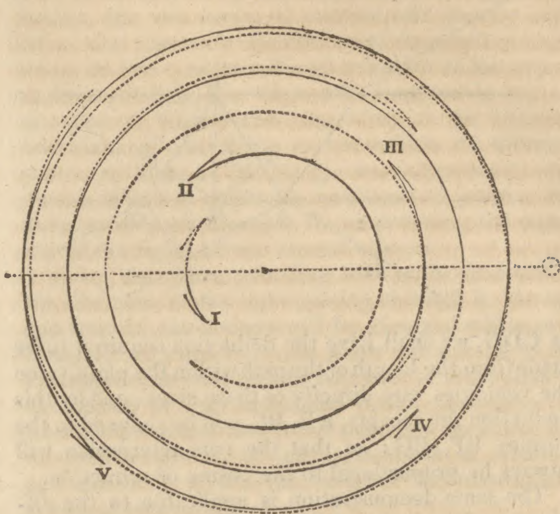
but forming a small angle with each other, so as to be differently inclined to the light passing through them. The effect of the inclination being to reduce the virtual thickness of the plate in the ratio of the cosine, and the difference of the cosines of equi-different arcs being simply as the sine of their half sum, it is evident that the colours must correspond to a thickness which varies nearly as the sine of the angle of incidence, considered with regard to a plane bisecting the angle formed by the plates: and this result agrees correctly with Dr Brewster's experiments.

SECTION VII.—*Of the Colours of Supernumerary Rainbows and Glories.*

Within the common primary rainbow, and without the secondary, we sometimes observe a partial repetition of colours, more or less distinctly marked, and extending occasionally to several alternations; the repetitions occupying somewhat narrower spaces as they are more remote from the ordinary bows. These appearances seem to have been first described by Mariotte; they have been since noticed by Langwith, Daval, and Dicquemare; and the term supernumerary rainbows has been very properly applied to them. The coloured circles, called glories, may generally be seen surrounding the shadows of our heads, when we have an opportunity of standing on a high hill, and observing them in a cloud below us: they are also sometimes accompanied by a large white circle, which, in an observation of Ulloa, was 67° in diameter: and such a circle may frequently be distinguished when the sun shines on a mass of vapour rising from a warm bath, of nearly the same dimensions, or sometimes a little smaller. The whole of these phenomena may be explained from the interference of some of the portions of light regularly reflected within the minute drops of water, with other portions, incident at a different angle, but, after an equal number of reflections, coinciding ultimately with them in direction; supposing only the clouds in question to afford a number of these drops varying but little from each other in diameter. We find by the well known mode of calculating the greatest deviation, that each order of reflections exhibits a zone from 30° to 10° in breadth, through which a double light is diffused by each drop; and besides this, when there have been more than three reflections, the portions belonging to the opposite sides cross each other in one or more points, and surround the drop; or rather the observer, if we consider the effect of the refraction of a multitude of drops situated in all directions. Supposing the index of refraction for the extreme rays 1.336, and its logarithm .1258000, the results will be these.

After	Extreme Deviation.	Final Deviation.
1 reflection	41° 40′	13° 52′
2	51 41	69 12
3	40 39	27 44
4	45 2	55 20
5	50 0	41 36
6	34 14	41 28

We may obtain a more distinct idea of these duplicatures, if we represent them in a diagram, showing the angular extent of the diffusion of light derived from each order of reflections, and distinguishing by different kinds of lines the portions belonging to the opposite halves of the drops: and it will be obvious from the inspection of this figure, that the appearances in question have only been observed within some of the duplicatures of the orders to which they belong, between the angles of extreme and of final deviation. The tertiary and quaternary bows (III. IV.) are evidently too near the luminary to be visible: the quinary (V.) ought to be seen in the space between the primary and secondary, but it is probably much too faint to be visible under any circumstances. The duplicature belonging to the primary rainbow exhibits two portions, for which we may calculate the interval of retardation in parts of the radius of the drop, supposing the velocity to be that which is appropriate to the air, by taking twice the difference of the cosines of incidence on the drop, and multiplying twice that of the cosine of refraction by the index 1.336; the difference of these differences giving the interval, for the two portions, of which the direction has been found to coincide by a previous calculation.



Distance from the Edge.	Angle of Reflection.	Difference of the Paths.
0°	40° 2′	.0000
1	42 59 36 23	.0014
2	44 2 34 32	.0040
3	44 45 33 3	.0074
4	45 20 31 45	.0113
5	45 46 30 34	.0160
6	46 9 29 26	.0210
8	46 45 27 20	.0327
10	47 12 25 24	.0461
12	47 32 23 33	.0612

Hence it may be inferred, that, supposing the extreme red to reappear at the distance of 2° from the primitive external termination of the rainbow, the radius of the drop must be $\frac{.0000266}{.004} =$ .00665, or $\frac{1}{150}$ of an inch; the fourth alternation of the red being at the distance of 5°, where the interval is .016. The magnitude of the interval, at an equal distance from the edge, varies but lit-

tle with the refractive density: thus, for violet light, the index of refraction being probably about 1.346, and its logarithm .1290000, the greatest deviation will be found $40^0\ 14'$; and for a deviation 2^0 less, the angles of refraction must be $43^0\ 30'$ and $33^0\ 47'$, and the interval will be little different from .00400.

The supernumerary bands of the secondary bow, formed by the same drops, will be a little broader than these, since it appears, from a similar calculation, that the rays interfering with each other, at the distance of a degree from the edge, will exhibit an interval of .0011 of the radius only, instead of .0014.

The supernumerary colours of the third and fourth bows will be equally imperceptible with the bows themselves: but the portions of light, four times reflected, will cross each other in the point opposite to the sun, where their coincidence will be perfect, and at other neighbouring points will afford an interval nearly proportional to the distance from that point. We shall find that the intervals for different deviations, supposed to be measured in air, are these.

Deviation.	Angle of Reflection.	Interval in parts of the Radius.
180^0	$24^0\ 49'$	.000
185	25 31	.096
175	24 7	
190	26 14	.195
170	23 25	

Hence, supposing the first bright or greenish ring to appear at the distance of 5^0 from the observer's head, the radius of the drops must be about $\frac{.0000225}{.096} =$ .000234, or $\frac{1}{4370}$ of an inch.

It might be questioned, whether the light, five times reflected, could retain sufficient force to produce any sensible effects by these interferences, but since it exhibits no appearance of colour between the primary and secondary rainbows, it must necessarily be extremely faint. The interval which it affords, by the comparison of its two portions, agrees sufficiently well with that which is derived from four reflections, to contribute in some measure to the production of an alternation of light and shade; but the separate colours would be rather weakened than strengthened by the mixture: thus, at the deviation of 5^0, the interval is found to become .076 instead of .096; and at 10^0, .155 instead of .195: and this difference is too considerable to allow us to expect any material increase of brilliancy from the addition of the fifth reflection, however great its intensity might be.

Supposing now a cloud to consist of spherules of which the radius is .000234, we may inquire at what distance from the outer edge of the primary rainbow the first additional red of the supernumerary colours ought to be found: the interval being in parts of the radius $\frac{.0000266}{.000234} = .116$: and we may infer from the table, by taking the successive differences, that this distance will be about 18^0; so that the semidiameter of this red ring will be $42 - 18 = 24^0$: and the termination of the primitive band of red, supposing it to extend to one fourth of a complete interval only, will be where the difference is .029, or at $7\frac{1}{3}^0$; but for the violet the quarter of the interval will be, in parts of the radius, $\frac{.0000042}{.000234} = .0183$, which answers to a distance from the edge of about $5\frac{1}{2}^0$: and this distance, measured from the edge of the violet, which is somewhat less than 2^0 within that of the red, will extend nearly to the same point as the red space: so that we shall have a circle, about 70^0 in diameter, at the circumference of which all the colours will be united, and which will consequently be white. This magnitude agrees tolerably well with the direct observations of the phenomenon; and if we wish to make the agreement more complete, we have only to suppose the drops a little smaller, and the coloured glories, which they are capable of affording, a little larger. It has already been remarked, that the nonappearance of the ordinary rainbow, in this case, must be referred to the operation of something like diffraction; although it is obvious that its form, under such circumstances, would necessarily be somewhat modified by the diffusion of the colours through a greater space than that which they ordinarily occupy.

Section VIII.—*Of the Colours of Striated Substances.*

It was observed by Boyle, that small scratches of any kind, on the surfaces of polished substances, exhibited, when viewed in the sunshine, a variety of changeable colours; and the observation may easily be repeated with any piece of metal, not too highly polished, and placed in a strong but limited light. Dr Young ascertained by experiment, that the colours afforded by some regular lines, drawn on glass, always corresponded to an interval, varying as the sine of the angle of deviation from the position, in which an image of the luminous object was exhibited by the regular reflection of the surface; and it is easily shown, that if we suppose two portions of light to be reflected from the opposite edges of the furrow, the difference of their paths must vary in that proportion. Dr Young had conjectured that the colours of the integuments of some of the coleopterous insects might be derived from furrows of this nature; but the conjecture has not been verified by observation. Dr Brewster has, however, very unexpectedly discovered, that some similar inequalities are the cause of the colours exhibited by mother of pearl; and he has confirmed the observation by showing, that impressions of the surface of this substance, taken in black wax, in a hard cement, or in fusible metal, will often exhibit a similar appearance. Where the form of the surface of the mother of pearl is the most regular, it reflects, in an oblique light, a white image of a luminous object, like that which any other polished substance affords; but on one side of this image only, and at some little distance from it, we may observe the first order of recurrent colours, beginning from violet, and occasioned in all probability by the reflections from one side only of an infinite number of parallel striae, formed by the terminations of a minute lamellated

structure, nearly, but not perfectly perpendicular to the general surface; one side only of each of the little furrows being situated in such a direction as to reflect an image of the luminous object to the eye, and at such a distance that the whole may constitute a regular series of equal intervals. By transmitted light, this substance generally appears of a red or a green colour, changing more or less according to the obliquity, and apparently belonging to some of the higher orders of recurrent colours.

Dr Young has observed a series of these colours, produced by the parallel lines of some of Coventry's glass micrometers, drawn at the distance of $\frac{1}{500}$ of an inch from each other, in which the first bright space, or the confine between the green and the red, corresponded to the interval of $\frac{1}{43000}$ of an inch, or .0000232 (*Medical Literature*, p. 559); and this result agrees very accurately with the general theory, the interval for the yellow, derived from Newton's measurements, being .0000235; but in general these lines exhibit colours much more widely extended, each separate line consisting in reality of two or more scratches, at a minute distance from each other.

There is a remarkable peculiarity in the appearance both of these colours, and of those which are exhibited by substances naturally striated, as by mother of pearl, agate, and some other semitransparent stones; they lose the mixed character of periodical colours, and resemble much more the ordinary prismatic spectrum, with intervals completely dark interposed. This circumstance may be satisfactorily deduced from the general law, if we consider, that each interference depends not only on two portions separated by a simple interval, but also on a number of other neighbouring portions, separated by other intervals which are its multiples; so that unless the difference of the two paths agrees very exactly with the interval appropriate to each ray, the excess or defect being multiplied in the repetitions, the colour will disappear; consequently each of the stripes, which in other cases divide the space, in which they appear, almost equally between light and darkness, when homogeneous light is employed, becomes here a narrow line; and their succession affords a spectrum exhibiting very little mixture of the neighbouring colours with each other, and nearly resembling that which is afforded by the simple dispersion of the prism; except that, as in all other phenomena of periodical colours, the blue and violet portions are much more contracted than in the common spectrum.

Section IX.—*Of the Colours of Mirrors, and of thick Plates.*

In all the species of periodical colours which have been described, the two portions of light concerned have both been regularly reflected from different surfaces. The methodical division of the subject now leads us to the consideration of the colours exhibited in light separately reflected from the same surface. These may be denominated in general the colours of mirrors; and they will include, as a variety, those which are called by Newton the colours of thick plates.

The general character of these colours is, that they are observed in light reflected by small particles, or irregularly dissipated by a single surface, first in the passage of the beam of light towards the mirror, and then in its return: the difference of the length of their paths affording, as usual, the interval of retardation. Thus in Dr Herschel's experiment of scattering a fine powder in a beam of light reflected perpendicularly by a concave mirror, and received on a screen in its return, it may easily be shown, that the colours will be precisely such as would be exhibited by light transmitted through a thin plate of air, every where half as thick as the plate limited by two spherical surfaces in contact; the centre of the one surface being the particle of powder, and that of the other its image formed by the mirror. For in the direction of the principal ray, which is perpendicular to the mirror, the paths of the light will be of equal length, whether the dissipation takes place before or after the reflection: and in other parts, the whole length of the path of the light passing from any focal point to its conjugate focus being the same, according to the definition of a conjugate focus in the Huygenian theory, from whatever point of the mirror it may be reflected, the light first dissipated will have advanced, after its reflection as far as the circumference of a circle, of which the conjugate focus is the centre, at the same instant that the portion coming directly from the powder, after a previous reflection, will reach the circumference of the circle of which the particle of powder is the centre; so that the distance between these two circles must be the difference of the paths of the two portions, and the colours the same as would be exhibited by a plate of air of half the thickness, since such a plate is twice traversed by the retarded light.

A similar appearance of colours had been obtained, by earlier experimenters, from the interposition of a screen of gauze, or of a semitransparent substance, in the path of the beam falling on the mirror. But the colours of thick plates, observed by Newton, are modified by the nature of the transparent substance employed, and by the obliquity of the refracted light. The dissipation here takes place at the anterior surface of a concave mirror of glass, and the reflection at the posterior, which is coated with quicksilver: and if these two portions proceed, each with a slight divergence, from a perforation in a screen situated near the centre of curvature of the mirror, they will cooperate perfectly with each other in the circumference of a circle described on the screen, of which the diameter is the distance of the perforation from its image; since all the light passing, in any given section of the mirror, with the same obliquity through the glass as the beam itself passes in the principal section, must be collected into a focal point situated in some part of this circle, and will arrive at this point at the same time whatever its situation in the section may have been: the obliquity of the incident light being the same in every part of the section, because the point of divergence is at the same distance from the mirror as the centre of curvature. For the other parts of the dissipated light, passing with different obliquities, the interval will be determined by the difference between the lengths of

the paths of the two portions of light arriving at the given point, the one by regular refraction, after being first dissipated and then reflected: the other by dissipation, after being first regularly refracted and reflected. And this interval agrees precisely with the law which Newton has deduced from his experiments: but the analogy, which he infers from it, between these colours and those of thin plates, is in fact very far from amounting to identity; since, if they belonged to the ordinary colours of thin plates, there is no reason why the series should begin anew from a certain arbitrary thickness, differing in every different experiment, which affords a white of the first order.

Section X.—*Of the Colours of deflected Light.*

We are next to examine the case of light only once reflected, and interfering with a portion of the same beam which has pursued its course without interruption: a case which would scarcely have required a separate consideration, but from the difficulty of including it in a general definition with any others; although it is comprehended in the Newtonian description of the colours of inflected light: but since the light is in this case turned away from the substance near which it passes, it may more properly be termed deflected, especially as the greater number of the appearances, mentioned by Newton, as depending on inflection, belong more properly to diffraction, and the term inflection might consequently be misunderstood as relating to them.

When a beam of light is received in a dark room, and suffered to fall upon the edges of two extremely sharp knives or razors, meeting each other in a very acute angle, the shadows of the knives, received on a screen at some distance, will be found to be bordered by several fringes of colours; and the angle will be bisected by a dark line. The distances from the shadows, at which these fringes appear, agree in general with the supposition of their depending on the interference of the light, reflected from the edges of the respective knives, with the uninterrupted light of the beam passing between them: but the coincidence of these portions ought to be perfect, in the immediate neighbourhood of the point in which the shadows meet, and the two last bright fringes ought to unite there in an angle of light. This, however, does not happen on account of the modification of the general law (C), which makes it necessary to allow half an interval for the effect of a very oblique reflection: and for the same reason, the space immediately next to the shadow is always dark instead of being light. If the knives are at all blunt, the reflection from one to the other, where they meet, causes the bisecting dark line to disappear; but this source of error may be avoided by causing one of them to advance a little before the plane of the other.

Mr Fresnel has repeated these experiments with all possible care, and has ascertained that the points, in which the fringes of any one colour are found, at different distances from their origin, belong always to a hyperbola, as they ought to do according to the calculation founded on the general law of interference; a fact which had before been inferred from other measurements, but which had not been so distinctly proved by direct experiments. Newton himself, indeed, was so far from believing that these fringes are rectilinear, as Mr Fresnel supposes, that he expressly mentions their curvature, and infers from it that they are not derived from "the same light" in all their parts; imagining, perhaps, that each fringe was of the nature of a caustic line, formed by reflection or refraction, in which the light is every where more condensed than in the collateral spaces, but which is by no means necessarily straight. Mr Fresnel has also shown, that all the fringes are found exactly at such distances from the true shadow, as would be inferred from the supposition of the loss of half an interval by reflection; while some of the experiments of Newton appeared to indicate a deviation from this law. It has been asserted, that fringes of the same kind have been observed at the edges of a detached beam of light, reflected into a dark space by a narrow plane and polished surface; and in this case it would be difficult to point out in what manner the supposed oblique reflection could be produced, or how a diffraction of any kind could cause the light to be redoubled back upon itself: but the experiment does not appear to have been hitherto performed with sufficient attention to all possible sources of error.

Section XI.—*Of the Colours of diffracted Light; including those of Fibres, and of Coronæ.*

The light reflected from each of the knife edges, in experiments like those of Newton, not only produces colours by its interference with the light proceeding uninterruptedly between them, but also with another portion, diverging from the edge of the opposite knife, and spreading into its shadow. This tendency of light to diffuse itself was first described by Grimaldi, under the appropriate name diffraction: but many of the phenomena, in which it is concerned, having been attributed by Newton to other causes, he appears almost to have overlooked its existence.

The general law of interference is very directly applicable to all phenomena of this kind: the fringes exhibited are broader in the same proportion as the distance between the edges is narrower; and they always depend on the difference of the distance from the edges as the interval of retardation. It is however necessary to suppose the same modification to take place in diffraction as in oblique reflection, half an interval being lost in both cases; since the light which deviates the least from a rectilinear direction, and which is derived from the near approach of the two paths to equality, is always white. But it is remarkable, that when the obliquity becomes a very little greater, the diffracted light seems to change its character in this respect; for the colours occupy the same spaces as would have belonged to them, if they had begun from a dark centre, one of the portions only having lost a half interval in comparison with the other: and of this circumstance no explanation has yet been attempted.

The diffraction producing these fringes may easily be detected within the eye itself, by holding any ob-

ject near it, in such a position as to intercept nearly all the light of a candle except a narrow line at the edge; this line will then appear to be accompanied by other lines parallel to it, separated from it by a dark space, and becoming wider when the object is brought nearer to the eye. These fringes must be referred to the light diffracted on one side round the object, so as to be spread on the unenlightened part of the retina, and reflected on the other from the margin of the pupil: for if we employ an object narrower than the pupil, so as to observe them on both sides of it, their magnitude will be altered by any change in the aperture of the pupil, occasioned by admitting light to the opposite eye, or otherwise. In such cases as this, where one of the points of divergence is much nearer to the point of interference than the other, the interval increases more rapidly than the distance from the primitive direction; and the first fringes are much broader than those which succeed them; the mode of their formation approaching to that of the fringes seen in deflected light, commonly called the exterior fringes of the shadow; while the interior fringes belong more immediately to the present subject, that of the colours of diffracted light.

When the distance of the points of divergence is more nearly equal, the one being collateral to the other, the breadth of the successive fringes is also more uniform. Such is the appearance of the colours exhibited by a number of equal fibres held between the eye and a distant luminous object; their origin being identical with those of the fringes produced in the shadows of the knives; except that the diffracted rays come from the remoter side of the fibres, and follow the reflected rays, instead of preceding them. These colours may easily be observed by looking at a candle through a lock of fine wool, and still more distinctly by substituting for the wool some of the seeds of the lycopodium, strewed on a piece of glass; and they become very large if we employ a few of the particles of the blood, or the dust of the lycoperdon, or puff ball. Dr Young has made this appearance the foundation of a mode of measuring the fineness of wool, which he has recommended for agricultural purposes, though it seems hitherto to have been found much too delicate to be employed by "the hard hands of peasants," with any advantage. The instrument, which he has invented for this examination, is called the eriometer, and its scale is calculated to express, in semidiameters of a circle, formed round a central aperture in a card, or a plate of brass, and marked by minute perforations, the distance at which the lock of wool must be held, in order that the first bright ring of colours, or the limit of the green and the red surrounding it, may coincide with the circle of points: and the actual measure, expressed by a unit of this scale, is found to agree very nearly with the thirty thousandth of an inch. Thus the particles of water, which have been found capable of exhibiting a glory 5^0 from the shadow of the observer, being about $\frac{1}{2183}$ of an inch in diameter, they would correspond to number 14 of this scale; and the cotangent of the angle subtended by the semidiameter of the bright circle being 14, the angle itself will be about 4^0; consequently, if we looked at the sun through such a cloud, he would appear to be surrounded by a bright circle of colours, 8^0 in diameter, green within, and red without, and attended by other colours, more or less distinctly marked, according to the degree of uniformity of the magnitude of the drops. These circles are called coronæ: their dimensions vary considerably; but they have seldom been observed quite so large as these drops would make them; and more commonly they seem to depend on drops about a thousandth of an inch in diameter; although it is not easy to ascertain the precise parts of the rings, from which the measures have been taken by different observers.

In the shadow of a larger substance, formed in a beam of light admitted into a dark room, these colours are still perceptible, beginning from a white line in the middle: but here both the portions, on which they depend, are diffracted into the shadow; and beyond its limits, they are lost in the stronger light that passes on each side of it. Their appearance is somewhat modified, when the shadow is formed by a body terminating in an angle; for the breadth of the fringes being inversely as the breadth of the object which forms them, it is obvious that this breadth must increase towards the point of the shadow, like the distance of the fringes formed in the shadows of Newton's knives: and the fringes seen within the angle must necessarily assume the character of hyperbolas: nor will this form be materially altered, when the angle becomes a right one, as in the crested fringes, noticed by Grimaldi; although the steps of the calculation, for determining their magnitude, are in this case a little more complicated.

We find, in an elegant experiment of Mr Biot, on the fringes produced by diffraction, a singular confirmation of the truth of the theory, which derives these colours from the difference of the times occupied in the passage of the different portions of light to the point of interference: although this celebrated author does not seem to have been aware of the nature of the inference, which may so naturally be drawn from it. He found that the densities of the substances, from the margin of which the diffracted light originated, had no influence whatever on the appearances produced by them: but when they were formed in the light diffracted from substances placed at one end of a long tube, and observed on a piece of glass fixed at the other end, they became contracted, upon filling the tube with water, in the proportion of 4 to 3; as was to be expected from the diminished velocity which must be attributed, according to the modification of the general law (B), to the passage of the light through a denser medium.

SECTION XII.—*Of the Colours of mixed Plates.*

The colours of mixed plates depend partly on diffraction, and partly either on reflection or on direct transmission: but their essential character consists in the different nature of the two mediums, through which the light passes after its separation

When a minute quantity of moisture is interposed

between two lenses, it readily divides itself into a great number of smaller portions, scarcely distinguishable by the eye: and the light transmitted through the lenses exhibits rings of colours much larger than those which are ordinarily observed, and depending on the interval afforded by the difference of the velocities in the different mediums, according to the inverse proportion of the refractive densities. If they are viewed in a direct and unconfined light, the rings belong to the series commonly seen by transmission, beginning from a light central spot: both portions passing in this case simply through the separate mediums, and arriving at the eye after some slight diffraction only, which affects both of them in an equal degree: but if a distant dark object is situated immediately behind the lenses, and they are illuminated by a light incident a little obliquely, their character is changed, and they resemble the colours commonly seen by reflection, one of the portions of light being necessarily reflected, as in the case of the colours of deflected light: so that, when the dark object is situated behind one half of the glasses only, we observe the halves of two sets of rings, of opposite characters, exhibiting everywhere tints complementary to each other. The diameters of the rings vary according to the refractive density of the liquid employed, diminishing as that density increases, and becoming much larger when two liquids, incapable of mixing with each other, and differing but little in refractive density, as oil and water, are employed instead of air and a single liquid.

The magnitude of the interval may also depend on that of a minute transparent solid substance, immersed in a liquid, instead of being limited by the distance of the two lenses: thus the dust of the lycoperdon, mixed with water, gives it a purplish hue, when seen by indirect, and a greenish by direct light: and when salt is added to the water, or oil is substituted for it, the difference of the velocities being lessened, the colours exhibited rise in the series, as if the plate were made thinner.

Mr Arago has very ingeniously applied the principle of the production of these colours, to the construction of an instrument, for measuring the refractive densities of different elastic fluids, and of air in different states of humidity; the fluids being contained in two contiguous tubes of a given length, through which the two portions of light are made to pass, previously to their reunion, and to the formation of the bands of colours; and it may easily be conceived, that the delicacy of such a test must be great enough for every determination that can be required, either for the correction of astronomical observations, or for the illustration of the optical properties of chemical compounds.

Section XIII.—*Of the Laws of the Polarisation of Light.*

The colours first observed by Mr Arago, in doubly refracting crystals, and since more particularly analysed by Mr Biot, afford by far the most striking and interesting examples of the colours of mixed plates. In order to understand the laws of these phenomena, it is necessary to be previously acquainted with the affections of polarised light, which were first accurately investigated by Malus, and with the theory of extraordinary refraction, derived by Huygens, with equal elegance and precision, from his peculiar hypothesis respecting the nature of the transmission of light.

1. Mr Malus discovered, that at a certain angle of incidence, the light partially reflected, by a transparent substance, receives a peculiar modification with respect to the plane of reflection, which is called *polarisation in that plane.*

2. Dr Brewster observed, that the *angle of complete* polarisation is such, that the mean direction of the transmitted light is perpendicular to that of the reflected portion; the tangent of the angle of incidence being equal to the index of the refractive density of the medium.

3. A ray of polarised light is again subdivided, in the usual proportion, by a second refraction in the plane of polarisation: but when it is refracted in a *plane perpendicular* to the plane of polarisation, by a surface properly inclined, *there is no partial reflection:* and in intermediate positions, the intensity of the reflection is nearly as the *square of the cosine* of the angular distance of the two planes.

4. A portion of the *transmitted* light is polarised in a *direction perpendicular* to that of the plane of refraction, so that none of this portion is reflected by a second surface parallel to the first; and when there are several parallel surfaces in succession, the whole of the transmitted light becomes at last so polarised, that none of it is partially reflected.

5. The same transverse polarisation will happen, in a *greater number* of transmissions, when the *angle differs* from that of complete polarisation: and in the same manner a second partial reflection, by a surface parallel to the first, will produce a more complete polarisation, when the first is imperfect.

6. A perfect polarisation in any new plane, by a partial reflection at the appropriate angle, completely *supersedes* the former polarisation: but a reflection or refraction void of any polarising effect, which may be called a *neutral* reflection or refraction, changes the direction of the plane of polarisation, according to Mr Biot's experiments, into that of the image of the former plane, supposed to be formed by the action of the given surface.

7. The light *ordinarily refracted* by a doubling crystal in the plane of the principal section of the crystal, passing through its axis, is *polarised in that direction:* the light *extraordinarily* refracted in the *transverse direction.*

8. Light *previously polarised* is transmitted by the ordinary refraction when its plane of polarisation coincides with the principal section, and by the extraordinary when it is perpendicular to it. In intermediate directions, the quantity of light transmitted by each refraction is, according to Malus, as the square of the cosine and sine of the angle formed by the planes, passing through the paths of the ray, and a line parallel to the axis in each crystal, supposing the species of refraction to be exchanged.

9. The rays of light ordinarily transmitted by doubling crystals appear in general to *retain their*

previous polarisation, like rays transmitted through simple substances; but the extraordinary refraction polarises them, according to Biot, like a neutral reflection at a surface coinciding with the principal section; the new plane of polarisation taking the place of the image of the former.

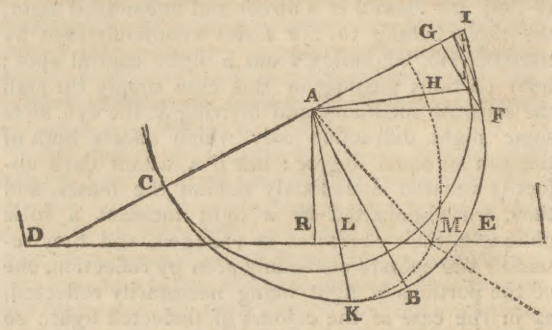
10. Reflections at *metallic surfaces* are generally neutral with respect to polarisation: but in oblique planes they seem, according to some experiments of Malus, to mix or depolarise the light subjected to them.

Section XIV.—*Of the Laws of extraordinary Refraction.*

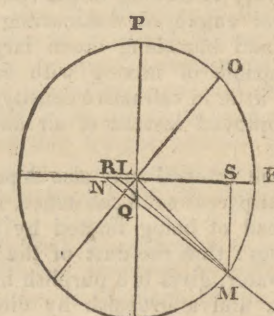
The extraordinary refraction of regular doubling crystals may be correctly determined in all circumstances, by means of the Huygenian supposition of an undulation diverging in the form of a spheroid, from every point of the medium, the velocity in any given direction being always proportional to the corresponding diameter, so that the successive spheroidal surfaces remain always similar to each other. The relations of the angles of incidence and refraction may be calculated by finding the point, in which any of the spheroids, supposed to represent the forms of the elementary undulations, at a given instant, is touched by a plane passing through that point of the surface, at which the original beam of light would have arrived, at the same instant, through the external medium; it may also be deduced, somewhat more simply, from the determination of the velocity, with which an expanding spheroidal undulation must extend itself on any given surface; a velocity which immediately gives us the direction of the ray in the surrounding medium; and the relation thus obtained will also obviously hold good with respect to a ray returning in the opposite direction. (*Quarterly Review, No.* 21.)

In common refractions, if we compare the space described by an undulation or any given surface with the radius, the velocities appropriate to the different mediums will be represented by the sines of the respective angles. But the velocity, with which a spheroidal undulation advances on any surface, is evidently determined by the increment, or the fluxion, of the perpendicular to the circumference of the section of the spheroid, formed by that surface; and calling this perpendicular y, the velocity may be considered as proportional to its increment y': but the velocity in the surrounding medium is to that, with which the axis x increases, as r to 1, r being the index of the ordinary refractive density of the crystal, compared with that of the surrounding medium, since the velocity in the direction of the axis is the same as that which belongs to the ordinary refractive density; consequently, the increment of the path of the undulation in the surrounding medium will be expressed by rx', and s, the sine of refraction or incidence without the crystal will be to the radius as rx' to y', and will be expressed by $\frac{rx'}{y'}$, or by $r\frac{dx}{dy}$, the evanescent increments of any quantities being always in the ratio of their fluxions: and the plane of refraction or incidence, without the crystal, will always be perpendicular to the tangent of the section formed by the refracting surface. The determination of the relation of the angles is therefore reduced to the calculation of the value of y and of its fluxion.

Supposing then the ratio of the greatest and least refractive densities of the crystal, or of the equato-



rial diameter of the spheroid 2AB to the axis 2AC to be that of n to 1, n being greater than unity, and the tangent of the angle ADE, formed by the axis with the refracting surface DE, being called p; the magnitude of the semidiameter AF, parallel to the surface, may be found by comparing the secants of the angles FAG, HAG, subtended at the centre by the corresponding ordinates of the ellipsis and the inscribed circle:



for their tangents, FG, HG, being represented by p and $\frac{p}{n}$, the secants will be $\surd(1+p^2)$, and $\surd\left(1+\frac{pp}{nn}\right)$; and the semidiameter of the circle, AH, being x, that of the ellipsis, AF, will be $n\surd\frac{1+pp}{nn+pp}x$. But the tangent of the angle GIF, made by the tangent of the ellipsis with the axis, is to that of the angle made by the corresponding tangent of the circle, GIH or GHA, that is, $\frac{n}{p}$, as n to 1; consequently, $\frac{nn}{p}$ will be the tangent of the angle made with the axis by the elliptic tangent, IF, or by the conjugate diameter AK; and if we substitute $\frac{nn}{p}$ for p, we shall find the length of this diameter $AK = \surd\frac{n^4+p^2}{nn+pp}x$, which is to that of the former AF in the ratio of $\frac{\surd(n^4+p^2)}{n\surd(1+pp)}$ to 1.

Chromatics. Hence, for the lesser semiaxis of the section formed by the given surface, EL, calling AL the distance of its centre from that of the spheroid, z, we have the mean proportional between the segments of the diameter $\surd([AK+AL]\cdot[AK-AL]) = \surd(AKq-ALq) = \surd\left(\frac{n^4+p^2}{nn+pp}x^2z^2\right)$, which must be reduced in the ratio of the conjugate diameters AK and AF, so that it becomes $n\surd\left(\frac{1+pp}{nn+pp}x^2 - \frac{1+pp}{n^4+p^2}z^2\right)$ $=$ EL. But from the known similarity of the parallel sections of a spheroid, the axes will be to each other as the semidiameter $AF = n\surd\frac{1+pp}{nn+pp}x$ is to nx the equatorial semidiameter, a ratio which may be called that of 1 to m, m being $=\surd\frac{nn+pp}{1+pp}$; so that the lesser axis EL being $=n\surd\left(\frac{xx}{mm} - \frac{1+pp}{n^4+p^2}z^2\right)$, the greater LP will be $n\surd\left(x^2 - \frac{1+pp}{n^4+p^2}m^2z^2\right)$.

Now, if q be the cotangent of the angle MNE, formed by the plane of the ray's motion, in the external medium, with the lesser axis of the section, or the tangent of the angle ELO formed by the conjugate semidiameter LO with the same axis, this semidiameter may be found by substituting q for p, m for n, and the value of the semiaxis of the section for x, in the expression for AF, the semidiameter parallel to the refracting surface, and it becomes $m\surd\frac{1+qq}{mm+qq}\,EL = n\surd\frac{1+qq}{mm+qq}\left(\frac{xx}{mm} - \frac{1+pp}{n^4+p^2}z^2\right)$ $=$ LO. Hence, since all parallelograms described about an ellipsis are equal, dividing the product of the semiaxes EL.LP by this semidiameter, we shall have the required perpendicular $y = MQ = \frac{EL.LP}{LO} = \frac{LP}{m}\surd\frac{mm+qq}{1+qq} = \frac{n}{m}\surd\frac{mm+qq}{1+qq}\surd\left(x^2 - \frac{1+pp}{n^4+p^2}m^2z^2\right)$. Now, in order to find the fluxion of this quantity, increasing as the spheroid increases, while the place of the centre of radiation remains unaltered, we must make z constant while x varies, and we shall have $dy = \frac{n}{m}\surd\frac{mm+qq}{1+qq}x\mathrm{d}x : \surd\left(x^2 - \frac{1+pp}{n^4+p^2}m^2z^2\right)$, which must be equal to $\frac{r\mathrm{d}x}{s}$; consequently, $\surd\left(x^2 - \frac{1+pp}{n^4+p^2}m\,z^2\right) = \frac{ns}{mr}\surd\frac{mm+qq}{1+qq}x$; and the lesser semiaxis of the section, EL, which was found $=\frac{n}{m}\surd\left(x^2 - \frac{1+pp}{n^4+p^2}m^2x^2\right)$, becomes $\frac{nns}{mmr}\surd\frac{mm+qq}{1+qq}x$, whence the semidiameter LM at the point of incidence, which may be called w, and which is analogous to the conjugate diameter AK in the former section, will be $\surd\frac{m^4+q^2}{mm+qq}\cdot\frac{nns}{mmr}\surd\frac{mm+qq}{1+qq}x$ $=\frac{nns}{mmr}\surd\frac{m^4+q^2}{1+qq}x$. Hence it is obvious, that this semidiameter, in any one plane of incidence, will be in a constant proportion to the sines, as Huygens himself demonstrated; so that, supposing x to be constant, and z to vary, the semidiameter w may be considered as an ordinate in the elliptic section passing through the point of incidence M and the diameter AK conjugate to the refracting surface, which is also the path of a ray falling perpendicularly on that surface from without: and the tangent of the angle ELM formed by this semidiameter with the lesser axis of the given section, will be $\frac{mm}{q}$, which determines the intersection of this oblique plane with the refracting surface. Chromatics.

But in order to find the angle made with the refracting surface in a plane perpendicular to it, we must compute LR, the distance of the centre of the refracting section from the point nearest to the centre of the spheroid: and the tangents of the inclinations of the diameters to the axis being p and $\frac{nn}{p}$, that of their mutual inclination will be $\frac{nn+pp}{p(1-nn)}$, since $\mathrm{ta}(a+b) = \frac{\mathrm{ta}a + \mathrm{ta}b}{1-\mathrm{ta}a\,\mathrm{ta}b}$; and the sine of the same angle being expressed by $\frac{\mathrm{ta}a+\mathrm{ta}b}{\sec a\sec b}$, it becomes here $\frac{nn+pp}{\surd(1+p^2)\surd(n^4+p^2)} = \sin$ FAK $=\sin$ ALR, which we may call τ, and the cosine $\frac{1-\mathrm{ta}a\,\mathrm{ta}b}{\sec a\sec b}$ $=\frac{p(1-nn)}{\surd(1+p^2)\surd(n^4+p^2)} = t$: and the required distance LR will be tz, and the distance of the centre of the spheroid from the refracting surface AR $=\tau z$. But MS, the perpendicular falling, from the point of incidence, on the lesser axis of the section formed by the surface, being called u, the tangent of the angle MLS, subtended by it at the centre being $\frac{mm}{q}$, and its sine consequently $\frac{mm}{\surd(m^4+q^2)}$, we have $u = \frac{mmw}{\surd(m^4+q^2)} = n^2\frac{sx}{r\surd(1+q)}$; and the distance of this perpendicular from the centre, LS $=v$ $=\frac{qw}{\surd(m^4+q^2)}$; or if we call the sine of ordinary refraction $\frac{s}{r} = \varrho$ and the sine of the inclination of

the plane of the ray's motion to the lesser axis, $\sqrt{\frac{1}{(1+qq)}}, k$, and its cosine $\frac{q}{\sqrt{(1+qq)}} = h$, we have $u = n^2\varrho kx$, and $v = \frac{nn}{mm}\varrho hx$. Hence the cotangent of the angle ERM, formed by the line nearest to the ray in the section with the lesser axis, will be $\frac{v+tz}{u}$, if the value of s be considered as positive, when the ray is inclined on the refracting surface towards the axis of the crystal; for in this case the sign of t being negative, tz or LR will be subtracted from v or LS; and the reverse when s is negative. We have also for the hypotenuse RM, or the distance of the point of incidence from the point nearest to the centre of the spheroid, $\sqrt{(u^2 + [v+tz]^2)}$; consequently, the tangent of RAM, the angle of incidence or refraction within the crystal, will be $\frac{\sqrt{(u^2+[v+tz]^2)}}{\tau z}$. Now since it has been shown that $\sqrt{(x^2 - \frac{1+pp}{n^4+p^2}m^2z^2)} = \frac{ns}{mr}\sqrt{\frac{mm+qq}{1+qq}}x$, we have $z^2 = \frac{n^4+p^2}{mm(1+pp)}\left(1 - \frac{nnss}{mmrr}\cdot\frac{mm+qq}{1+qq}\right)x^2$, and the cotangent of the inclination of the plane of refraction ERM, or $\frac{v+tz}{u} = \frac{q}{mm} + \frac{tz}{u}$, becomes $\frac{q}{mm} + \frac{p(1-nn)}{m(1+pp)}\sqrt{\left(1 - \frac{nn}{mm}[m^2k^2+h^2]\varrho^2\right)}\cdot\frac{1}{nn\varrho k}$; and since $\tau^2z^2 = (m^2 - n^2\varrho^2[m^2k^2+h^2]\,x^2$, the tangent of the angle of incidence or refraction within the crystal, which is $= \sqrt{\left(\frac{uu}{\tau\tau zz} + \frac{vv}{\tau\tau zz} + \frac{2t}{\tau}\cdot\frac{v}{\tau z} + \frac{tt}{\tau\tau}\right)}$ will be represented by $\sqrt{\left(\frac{n^4m^4k^2+n^4h^2}{m^4(m^2 - n^2\varrho^2[m^2k^2+h^2])}\varrho^2 + \frac{2p(1-nn)nnk\varrho}{(nn+pp)mm\sqrt{(m^2 - n^2\varrho^2[m^2k^2+h^2])}} + \left[\frac{p(1-nn)}{nn+pp}\right]^2\right)}$. The value of the perpendicular to the surface, AR or τz, is also of importance as immediately indicating, by its proportion to the axis x, the velocity of the undulation in the direction of the depth, which is therefore represented by $\sqrt{(m^2 - n^2\varrho^2[m^2k^2+h^2])}$.

These expressions become somewhat simpler in many cases of common occurrence; thus, when the axis is parallel to the surface, $p = 0$, $m = n$, and $t = 0$, consequently, the tangent of refraction is $\frac{\varrho}{n}\sqrt{\frac{n^4k^2+h^2}{1\,(nnkk+hh)\varrho\varrho}}$, and the perpendicular velocity $n\sqrt{(1 - [n^2k^2+h^2]\varrho^2)}$. When the axis is perpendicular to the surface, p is infinite, $m = 1$, and t is again $= o$; and the tangent of the angle of refraction is $\frac{nn\varrho}{\sqrt{(1-nn\varrho\varrho)}}$, the perpendicular velocity being $\sqrt{(1-n^2\varrho^2)}$.

The retardation, produced by the passage of light through such a plate, being equal to the time occupied within the plate, diminished by a time proportional to the product of the tangent of the angle of refraction and the sine of the angle of incidence (see Section V.); it will be expressed, in the case of a plate parallel to the axis, by $\frac{r}{n\sqrt{(1-[nnkk+hh]\varrho\varrho}} - s\varrho\sqrt{\frac{n^4k^2+h^2}{1-(nnkk+hh)\varrho\varrho}}$; and when the axis is perpendicular to the plate, by $\frac{r}{\sqrt{(1-nn\varrho\varrho)}} - \frac{snn\varrho}{\sqrt{(1-nn\varrho\varrho)}} = \frac{r(1-nn\varrho\varrho)}{\sqrt{(1-nn\varrho\varrho)}} = r\sqrt{(1-nn\varrho\varrho)}$. The effect of any small change in the form of the spheroid, on the retardation, may be found from the fluxions of these quantities, supposing n to vary; which, when properly reduced, making $n = 1$, will be $-r\frac{1-hh\varrho\varrho}{\sqrt{(1-\varrho\varrho)}}\mathrm{d}n$, and $-\frac{r\varrho\varrho}{\sqrt{(1-\varrho\varrho)}}\mathrm{d}n$ respectively.

The values of r and n, for the principal substances, exhibiting the extraordinary refraction, which have been examined, are these:

Iceland crystal	$r = 1.657$	$n = 1.1140$	=	10 : 9
Arragonite . . .	1.693	1.1030	=	11 : 10
Ice	1.310	.9989	=	890 : 891
Quartz	1.558	.99444	=	179 : 180
Sulfate of lime	1.525	.99432	=	175 : 176
Sulfate of barita	1.635	.99295	=	142 : 143

In mica, according to Mr Biot, and in arragonite, according to Dr Brewster, there are two axes of crystallization; and the refraction of such substances may probably be represented, by supposing all the circular sections of a spheroid to become ellipses, so that the undulation may assume the shape of an almond.

Section XV.—*Of the Colours of doubly refracting Substances.*

In the case of doubly refracting substances, the first difficulty is, not to explain why the colours of double lights are sometimes produced, but why they are not more universally observable: since it might naturally be expected, as a consequence of the general law of interference, that two portions of the same beam, passing through a moderately thin plate of such a substance, in paths differing but little from each other, and coinciding again in direction, should, in all common cases, exhibit colours nearly similar to those of ordinary thin plates. It would, however, be difficult to conjecture, whether they ought to resemble the colours seen by transmission or by reflection; and the fact is, that both these series of co-

lours are at once produced by the substances in question; but they are so mixed, that, without a particular arrangement, they always neutralise each other: and their formation appears to be also limited to certain peculiar conditions of polarisation, consistent with Mr Arago's observation, on the non-interference of two portions of light, polarised in transverse directions. Several of the cases, indeed, in which they are exhibited, remain still involved in some degree of obscurity; but it is easy to analyse the most important of the phenomena, and to reduce them, with great precision, to the general laws of periodical colours.

Mr Malus has demonstrated, by satisfactory experiments, that a beam of light, admitted into a doubly refracting crystal, is as much divided by partial reflection at the second surface, as by transmission at the first: the directions and the relative intensities of the two portions being precisely the same as those of the two portions of a ray similarly polarised, and returning to the second surface from without in an equal angle; so that, after a farther transmission at the first surface, all the portions become again parallel. When the ray is in the direction of the principal section, there is no separation, each of the pencils proceeding undivided, as they would do if they passed through a second crystal parallel to the first: and the separation becomes the most complete when the plane of incidence makes an angle of about 45° with the principal section; each of the portions o and e, into which the ray is divided upon its admission, affording then two reflections, oO and oE, eO and eE, of nearly equal intensity. The times occupied by the portions oO, eE, will differ most from each other, while oE and eO will describe their paths in equal times of intermediate length: but of these eO only will commonly interfere with oO, which has a similar polarisation in the plane of incidence, and oE with eE, both being polarised in a transverse direction; so that we have two series of colours, depending on an equal interval, except so far as they are distinguished by the inversion of one of the portions belonging to the extraordinary reflection, which renders the series of colours exhibited by them similar to that of the colours of common thin plates seen by reflection, while the ordinary reflection exhibits colours analogous to those of thin plates seen by transmission.

Mr Biot's usual mode of exhibiting these colours is to place a thin plate of sulfate of lime, or of any other crystal, on a black substance; to allow it to reflect the white light of the clouds at an angle of incidence of about 55°; and to receive this light on a black glass, at an equal angle of incidence, in a plane transverse to the former, so that the plate may be viewed by reflection in the black glass. In this arrangement, the light reflected from the upper surface of the plate, being polarised in the first plane of reflection, is not reflected by the black glass, and consequently is incapable of rendering the colours less easily perceptible by admixture with them: the beams oO and eO, returning by the ordinary reflection, are also similarly polarised, and will be transmitted or absorbed by the glass; but the beams oE and eE, being polarised in a transverse direction, will be partially reflected by it, and will exhibit a very brilliant colour, depending on their mutual interference. If, on the contrary, the black glass be turned round the ray, so that the second plane of incidence may coincide with the first, the ordinary rays only will be partially reflected by it, and the complementary colour will be exhibited by the union of the portions oO, eO; but this colour will be less distinct, on account of its mixture with the white light reflected by the first surface.

Appearances of a similar nature may also be observed in the transmitted light; each of the refractions exhibiting the colour complementary to that which it affords by reflection, as happens in the ordinary colours of thin plates; and we must seek for the portions of light which afford them, in the successive partial reflections at the two surfaces of the plate, as in the case of the ordinary colours; the light simply transmitted by the separate refractions not exhibiting the ordinary effects of interference, for want of a similarity of polarisation. The obliquity of the incident light produces similar effects on both series.

Under some circumstances of the reflection of rays near the perpendicular, Mr Biot observes that the plate assumes the colour which is usually exhibited by a plate of twice the thickness viewed a little more obliquely: and in such cases it is probable that the polarisation of the beams oO and eE has been so modified as to afford a partial interference; and if this is not the true explanation, it will not be difficult to suppose the interval to be doubled in some other manner by a repeated reflection.

The effect of a plate of a double thickness is also produced by two equal and parallel plates, through which the light passes in succession, provided that their axes of crystallization be parallel, and that they be of such a thickness, as to exhibit in conjunction a colour more easily observable than those which they afford separately: a condition which is more generally applicable to the case in which the axes are transverse to each other, and one of the thicknesses is to be subtracted from the other; since in this situation the two portions of light must always interchange their refractions, and that which has moved the more slowly, in its passage through one of the plates, will move the more rapidly in the other. This result is very accurately confirmed by experiment, and certainly affords a very striking illustration of the truth of the law of interference.

When we wish to examine the effects of the different obliquities of the incident light, it is most convenient to employ a beam previously polarised, which renders the separation of the different portions by a subsequent reflection or refraction more easily practicable: and for these purposes we may either make use of plates of black glass, placed in proper situations, or polarising piles, consisting of a number of oblique thin plates, which produce the effect, on the light transmitted through them, with less diminution of its intensity than would take place in a single partial reflection. In some cases also, the light may be analysed by causing it to pass through

a piece of Iceland crystal; or through a thin plate of agate, which Dr Brewster has found to transmit only such light as is polarised in a particular plane.

The measurements of the thickness of plates of doubly refracting substances agree in general very accurately with the various tints exhibited by them in various situations with respect to the axis, and with various obliquities of the incident light, according to the theory of periodical colours: and the agreement is always sufficiently perfect to convince us of the dependence of the phenomena on the law of interference, even if it should happen to require some unknown modification in particular cases. In the first place, when the incidence is perpendicular, the thickness of the plates is precisely such as would be inferred from the theory, at least as nearly as the theory is founded on observations sufficiently accurate, although this thickness is often many hundred times as great as that of the thin plates, with which it is to be compared: thus the greatest disproportion of the ordinary and extraordinary refraction of rock crystal, according to Malus's experiments, is that of 159 to 160; so that the difference of the times, occupied by light in passing through this substance, is to the interval, in virtue of which a similar plate exhibits the common colours, as 1 to 320, and to the interval in a plate of crown glass as 1 to 318; while the experiments of Mr Biot make the observed proportion that of 1 to 360; the difference being no greater, than would arise from an error of less than a thousandth part of the whole, in the determination of one of the refractive densities.

The effect of the obliquity of the incident light, on the colours exhibited by plates of rock crystal, agrees also perfectly with the theory. The difference of the times required for the ordinary and extraordinary refractions, which is always comparatively small, will vary as the fluxion of the retardation, when the obliquity varies; and the sine of ordinary refraction being ϱ, the interval will be expressed by $-r\frac{1-hh\varrho\varrho}{\surd(1-\varrho\varrho)}\,dn$, when the axis is parallel to the surface of the plate, and by $-r\frac{\varrho\varrho}{\surd(1-\varrho\varrho)}\,dn$, when it is perpendicular. Taking, for example, an experiment of Mr Biot, on a plate in which the axis was nearly perpendicular, the mean angle of refraction being 21° 38.5′, the tint was a reddish white of the seventh order, answering to the reflection from a plate of glass .0000496 of an inch thick, in the experiments of Newton, while the colour exhibited, in a perpendicular light, by a plate of the same crystal, in which the axis was parallel to the surface, would have been expressed by the thickness .000332. In these two cases, the values of the fluxion become $-r\,dn$ and $-.14633r\,dn$; and reducing the interval .000332 in this proportion, we find .0000486 for the thickness of a plate of glass which ought to exhibit the tint corresponding to the oblique incidence; the difference from the experiment being only one millionth of an inch, which would scarcely make a sensible alteration in the colour observed. When the thickness of such a plate is more considerable, or when the eccentricity of the extraordinary refraction is greater, the colours differ, with the incidence, in different parts of the plate; and they are generally disposed in rings concentric with the axis. These rings have been particularly described by Dr Brewster, as observed in the topaz: they are always interrupted by a dark cross, occasioned by the want of light, properly polarised to afford them, in the two transverse directions.

Mr Biot has made a great number of experiments on the colours of the plates of sulfate of lime, in the form denominated Muscovy talc: they exhibit a general agreement with the results of the calculation, particularly with respect to the constancy of the tint, in all moderate obliquities, when the inclination of the axis to the plane of incidence is 45°; but in other cases the agreement is somewhat less perfect, and the difference is too great to be attributed altogether to accident. The most probable reason for this irregularity, under circumstances so nearly similar to those which accord with the theory in the case of rock crystal, is the want of a perfect identity of the two refractions, in the direction of the supposed axis; or, in the language employed by Mr Biot with respect to mica, the existence of a double axis of extraordinary refraction: and it is the more credible that such a slight irregularity may have existed in the sulfate of lime without having been observed, as Dr Brewster has lately detected a similar property in the arragonite, though both Malus and Biot had examined this substance very carefully without being aware of it. The calculation of the extraordinary refraction, in such a case, would afford but little additional difficulty, if its characters were well determined: the form, in which the undulations must be supposed to diverge, might properly be termed an *amygdaloid;* and the velocities with which the sections, formed by the given surface, would extend themselves, might be deduced from the properties of the ellipsis, nearly in the same manner as they have been determined for the spheroid. The difference of the results of the calculation from the spheroid, and of Mr Biot's experiments, or rather of the empirical formula, derived from them, may be seen in the subjoined table; the first part of which, deduced from the theory, is applicable to all substances affording a regular extraordinary refraction, when the axis is either perpendicular or parallel to the surface of the plate. The first column of decimals shows the equivalent variation of thickness where the axis is perpendicular to the plate, being equal to $\frac{\varrho\varrho}{\surd(1-\varrho\varrho)}$, the product of the sine and tangent of refraction; the second represents the variation for an ordinary thin plate, being proportional to the cosine $\surd(1-\varrho\varrho)$; and the subsequent columns are found by adding to the numbers of the second column those of the first, multiplied by k^2, the square of the sine of the inclination of the plane of incidence to the axis, since $\frac{1-hh\varrho\varrho}{\surd(1-\varrho\varrho)}=\surd(1-\varrho\varrho)+\frac{kk}{\surd(1-\varrho\varrho)}$.

Angle of Refraction.	Perpendicular Plate.	Parallel Plate. Inclination of the Plane of Incidence to the principal Section. 0°	22½°	45°	77½°	90°
00°	.0000	1.0000	1.000	1.000	1.000	1.000
20	.1245	.9397	.958	1.002	1.046	1.064
40	.5394	.7660	.845	1.036	1.245	1.305
60	1.5000	.5000	.720	1.250	1.780	2.000
80	5.5851	.1736	.992	2.966	4.940	5.759
Biot.						
20		.969	.975	.995	1.023	1.038
40		.898	.920	1.000	1.112	1.175
60		.848	.882	1.097	1.396	1.588
80		1.196	.921	1.440	2.338	3.562

There are also some circumstances in the experiments of Mr Biot on plates of rock crystal cut perpendicularly to the axis, which cannot be sufficiently explained on any hypothesis, without some further investigation. These plates seem to transmit the beam of light subjected to the experiment, without materially altering its polarisation, and then to produce different colours, according to the situation of the substance subsequently employed for analysing the light: so that Mr Biot supposes the rays of light to be turned more or less by the crystal, round an axis situated in the direction of their motion; and he has observed some similar effects in oil of turpentine, and in some other fluids. But it is highly probable, that all these phenomena will ultimately be referred to some simpler operation of the general law of interference.

Dr Seebeck and Dr Brewster have discovered appearances of colours, like those of doubly refracting substances, in a number of bodies which can scarcely be supposed to possess any crystalline structure. They are particularly conspicuous in large cubes of glass, which have been somewhat suddenly cooled, so that their internal structure has been rendered unequal with regard to tension. The outside of a round mass, thus suddenly cooled, being too large for the parts within it, must necessarily be held by them in a state of compression with respect to the direction of the circumference, while they are extended in their turn by its resistance: although in the direction of the diameter the whole will generally be in a state of tension: so that the refractive density may naturally be expected to be somewhat different in different directions, which constitutes the essential character of oblique refraction: and when the proportions of the external parts to the internal are modified by the existence of angles, or other deviations from a spherical form, the arrangement of the tensions must be altered accordingly: and there is no doubt that all the apparently capricious variations of the rings and bands of colours, which are observed, might, by a careful and minute examination, be reduced to the natural consequences of these inequalities of density, so far at least as the laws of the extraordinary refraction alone are concerned, although the separation of the light into two portions might still remain unexplained. Effects of the same kind are produced by the temporary operation of partial changes of temperature, producing partial compression and extension of the internal structure of the substance: and even a mechanical force, if sufficiently powerful, when applied externally in a single direction, has been shown, by the same observers, to produce a double refraction; although the difference of the densities, thus induced, is much too minute to be perceived in any other way, than by means of these colours, which are, in general, so much the more easily seen, as the cause which excites them is the feebler.

Dr Brewster has also shown, that the total reflection of light within a denser medium, and the brilliant reflection at the surfaces of some of the metals, are capable of exhibiting some of the appearances of colour; as if the light concerned were divided into two portions, the one partially reflected in the first instance, the other beginning to be refracted, and caused to return by the continued operation of the same power. In the case of silver and gold, it has already been observed, that there appear to be two kinds of reflection, occasioning opposite polarities; and these may possibly be concerned in the production of this phenomenon. The original interval appears to be extremely minute, but it is capable of being increased by a repetition of similar reflections, as well as by obliquity of incidence. Mr Biot has also found that such surfaces, combined with plates of doubly refracting substances, either increase or diminish the equivalent thickness, according to the direction of the polarisation which they occasion. In these and in a variety of similar investigations, a rich harvest is opened, to be reaped by the enlightened labours of future observers; and the more difficulty we find in fully explaining the facts, upon the general principles hitherto established, the more reason there is to hope for an extension of the bounds of our knowledge of the optical properties of matter, and of all the laws of nature connected with them, when the examination of these apparent anomalies shall have been still more diligently pursued.

Section XVI.—*Of the Nature of Light and Colours.*

Notwithstanding the acknowledged impossibility of fully explaining all the phenomena of light and colours by any imaginable hypothesis respecting their nature, it is yet practicable to illustrate them very essentially, by a comparison with the known effects of certain mechanical causes, which are observed to act in circumstances somewhat analogous; and as far as a theory will enable us to connect with each other a variety of facts, it is perfectly justifiable to employ it hypothetically, as a temporary expedient for assisting the memory and the judgment, until all doubts are removed respecting its actual foundation in truth and nature. Whether, therefore, light may consist merely in the projection of detached particles with a certain velocity, as some of the most celebrated philosophers of modern times assert, or whether in the undulations of a certain ethereal medium, as Hooke and Huygens maintained, or whether, as Sir Isaac Newton believed, both of these causes are concerned in the phenomena; without positively admitting or rejecting any opinion as demonstrably true or false, it is our duty to inquire what assistance can be given to our conception and

recollection, by the adoption of any comparison, which may be pointedly applicable even to some insulated facts only. It has however been thought desirable to separate this investigation, as much as possible, from the relation of the facts, in order to avoid confounding the results of observation with the deductions from mere hypothesis; an error which has been committed by some of the latest and most meritorious authors in this department. It may be objected to some of the preceding sections, that this forbearance has not been exercised with respect to the general law of interference and its modifications: but it would have been impossible to give any correct statement of the facts in question, without determining whether the appearances depend upon one or both of the portions of light supposed to be concerned.

Art. 1. (Sect. I.) The separation of colours is explained, in the hypothesis of emission, by the supposition of an elective attraction, different in intensity for the different rays of the spectrum: but for this difference no ulterior cause is assigned. Any original difference of velocity is contrary to direct experiment; and even the alterations of relative velocity, which must inevitably be occasioned by a variety of astronomical causes, have not been detected by the most accurate observations, instituted for the express purpose of discovering them: so that it has been suggested, that there may possibly be a multitude of rays of the same colour, moving with various velocities, and only affecting the sense when they have the velocity appropriate to that colour in the eye. The name of elective attraction is indeed little more than a mode of expressing the fact, without referring it to any simpler mechanical cause: and in chemical elective attractions the substances concerned are under very different circumstances, with respect to contact, and with respect to the probable influence of the form and bulk of their integral particles; at the same time it seems impossible to show any absurdity in the supposition of the existence of such an elective attraction with regard to the different kinds of light. On the other hand, if we consider colours as depending on a succession of equal undulations, of different magnitudes as the colours are different, we may discover an analogy, somewhat more approaching to a mechanical explanation, in the motions of waves on the surface of a liquid: the largest waves moving with the greatest rapidity, although the approximate calculation, derived from the most approved theory, leads us to the same expressions for the velocity, as are applicable to the transmission of an impulse through an elastic fluid. The fact is, that a larger wave moves more rapidly than a smaller, because the pressure is not precisely limited to a perpendicular direction, as the simplest calculation supposes, but operates also more or less in an oblique direction, principally within a certain angular limit; so that the utmost depth, at which any difference of pressure can affect the liquid as a motive force, is that at which this angle may be imagined to comprehend virtually the exact breadth of a wave; and since the velocity depends on the depth of the fluid affected at once by the pressure, the breadth becomes in this manner an element of the determination. Thus also the larger undulations, constituting red light, are found to move more rapidly than those of the violet, which are supposed to be smaller; and there are many ways in which the difference may be supposed to be occasioned, although not depending exactly on the same cause as in the case of the waves on the surface of a liquid. It is well known that sounds of all kinds move with an equal velocity through the air; and all colours arrive through the supposed elastic ether in the same time from the remotest planets: but a refractive medium, however transparent, is not to be considered as perfectly homogeneous: in many instances, two mediums, of different qualities, seem to pervade every part of a crystal, which is completely uniform in its appearance; and it seems to be necessary, in every case, to suppose the particles of material bodies scattered at considerable distances through a medium which passes freely through their interstices; so that we may conceive the undulations of light to be transmitted partly through the particles themselves, and partly through the intervening spaces, the two portions meeting continually after a certain very minute difference in the length of their paths: we may then suppose the portion transmitted through the interstices to be weakened by the irregularity of its passage, which will affect the smaller undulations more than the larger: and when these portions are combined with the portions more slowly transmitted through the particles themselves, these last will bear a greater proportion to the former in the violet than in the red light, and will have more influence on the ultimate velocity, which will therefore be smaller for the violet than for the red. This explanation may perhaps be far from the best that the hypothesis in question might afford; but it will serve as an illustration of a possible mode, in which the phenomenon may be referred to the established laws of mechanics, without the continual introduction of new principles and properties.

Art. 2. (Sect. IV. A.) Most of the ordinary phenomena of optics are capable of a sufficiently satisfactory explanation, on either of the hypotheses respecting the nature of light and colours: but the laws of interference, which have been shown to be so extensively applicable to the diversified appearances of periodical colours, point very directly to the theory of undulation: so directly, indeed, that their establishment has been considered, by many persons on the Continent, as almost paramount to the establishment of that theory. It might not, however, be absolutely impossible, to invent some suppositions respecting the effects of light, which might partially reconcile these laws to the theory of emission. Thus, if we suppose, with Newton, the projected corpuscles of light to excite sensation by means of the vibrations of the fibres of the retina and of the nerves, we may imagine that such vibrations must be most easily produced by a series of particles following each other at equal distances, each colour having its appropriate distance in any given medium: it will then be demonstrable, that any second series of similar particles, interfering with them, in such a manner as to bisect their intervals, will destroy their effect

in exciting a vibratory motion; each succeeding particle meeting the fibre at the instant of its return from the excursion occasioned by the stroke of the preceding, and thus annihilating the motive effect of that stroke. But the illustration ends here: for it seems impossible to adapt it to the greater number of the alternations which occur, during the passage of a ray, through a given space, in a denser medium: since it is an indispensable condition of the projectile theory, that the velocity of light should be increased upon its entrance into a medium of greater refractive density. The Newtonian theory, of fits of easy reflection and easy transmission, is still more limited in its application; since it attributes to one portion of light those effects, which have been strictly demonstrated to depend on the presence of two.

In the undulatory theory, the analogy between the laws of interference, and the phenomena of the tides, and the effects of the combination of musical sounds, is direct and striking. The existence of an undulation of an elastic medium depends on the recurrence of opposite motions, alternately direct and retrograde, at certain equal distances, in the same manner as a series of waves consists in a number of alternate elevations and depressions, and the succession of the tides in a number of periods of high and low water. The spring and neap tides, derived from the combination of the simple solar and lunar tides, afford a magnificent example of the interference of two immense waves with each other: the spring tide being the joint result of the combination when they coincide in time and place, and the neap when they succeed each other at the distance of half an interval, so as to leave the effect of their difference only sensible. The tides of the port of Batsha, described and explained by Halley and Newton, exhibit a different modification of the same opposition of undulations; the ordinary periods of high and low water being altogether superseded, on account of the different lengths of the two channels by which the tides arrive, affording exactly the half interval which causes the disappearance of the alternation. It may also be very easily observed, by merely throwing two equal stones into a piece of stagnant water, that the circles of waves, which they occasion, obliterate each other, and leave the surface of the water smooth, in certain lines of a hyperbolic form, while, in other neighbouring parts, the surface exhibits the agitation belonging to both series united. The beating of two musical sounds, nearly in unison with each other, appears also to be an effect exactly resembling the succession of spring and neap tides, which may be considered as the beatings of two undulations, related to each other in frequency as 29 to 30; and the combination of these sounds is still more identical with that which this theory attributes to light; since the elementary motions of the particles of the luminiferous medium are supposed to be principally confined to the line of direction of the undulation, while the most sensible effects of the waves depend immediately on their ascent and descent, in a direction perpendicular to that of their progressive motion.

Art. 3. (Sect. IV. B.) The diminution of the velocity of light upon its entrance into a denser medium, in the direct proportion of the refractive density, is one of the fundamental principles of the undulatory theory, and is perfectly inadmissible on the supposition of projected corpuscles. But it must be remembered, that the demonstration of the actual existence of this proportion is somewhat indirect; being only derived from the necessity of admitting it, in the application of the laws of interference to the observed phenomena: and we have no means of obtaining an immediate measure of the velocity of light in different mediums.

Art. 4. (Sect. IV. C.) The loss of the half interval may be explained, in particular cases, without difficulty, although, in other instances, the circumstances are too complicated to allow us to appreciate their effects. In the direct transmission of a ray of light through a plate of a transparent substance, we may compare the denser medium to a series of elastic balls, larger and heavier than another series in contact with them on each side. Now, it is well known that a series of elastic balls transmits any motion from one end to the other, while each ball remains at rest, after having communicated the motion to the next in order; so that the last only flies off, from having none beyond it to impel: and if the balls, instead of being only possessed of repulsive forces, were connected by elastic ligaments of equal powers, a motion in a contrary direction would be transmitted with equal ease; the last ball, being retained by the ligament, instead of flying off, would draw the last but one in the same direction, itself remaining at rest after this negative impulse; and the motion would be communicated backwards in the same manner throughout the series to the first ball; and then, for want of further resistance, this ball would not remain at rest after receiving the negative impulse, but would be drawn forwards by it, so as to strike the second, precisely in the same manner as at the beginning of the experiment; and this second positive impulse would proceed through the whole series like the first. Such is the nature of the longitudinal vibrations of elastic rods, first observed by Chladni; the cohesion of the substance supplying the place of the supposed elastic ligaments: and in the case of an elastic fluid, the pressure of the surrounding parts performs the same office; a negative impulse being always propagated through it with the same facility as a positive one. If, instead of a single series of balls, we now consider the effect of two series, the second consisting of larger balls than the first, the last ball of the smaller series will not remain at rest after striking the first of the larger, but will be reflected, so as to strike the last ball but one in a retrograde direction; and this retrograde impulse will be continued to the first ball, constituting a positive impulse with respect to the new direction, in which it is propagated. But if the first series of balls be larger than the second, the last of the larger balls will not be deprived of all its motion by striking the first of the smaller, but will continue to move more slowly in its first direction; and the elastic ligaments will then be called into action, so as to carry back, step by step, to the first ball, this remaining impulse, which will become negative with respect to the new direction of its transmission. And the same must

happen in the case of two elastic mediums in contact, supposing them to be of equal clasticity, but of different densities; the direction of the elementary motions either coinciding with that of the general impulse, or being opposite to it in both mediums at once, when the reflection is produced by the arrival of the undulation at the surface of a denser medium, and being reversed when at the surface of a rarer: and it is obvious that such an inversion of any regular undulation is paramount to its retardation or advancement, to the extent of half of the interval which constitutes its whole breadth; every affection of such an undulation being precisely inverted, at the distance of half the breadth of a complete alternation: and these effects will not materially differ, whether the impulse be supposed to arrive perpendicularly at the surface, or in an oblique direction.

Art. 5. (Sect. IV. D.; Sect. XIII.) The experiments of Mr Arago, not yet published in detail, which show that light does not interfere with light polarised in a transverse direction, lead us immediately to the consideration of the general phenomena of polarisation, which cannot be said to have been by any means explained on any hypothesis respecting the nature of light. It is certainly easier to conceive a detached particle, however minute, distinguished by its different sides, and having a particular axis turned in a particular direction, than to imagine how an undulation, resembling the motion of the air which constitutes sound, can have any different properties, with respect to the different planes which diverge from its path. But here the advantage of the projectile theory ends; for every attempt to reduce the phenomena of polarisation to mechanical laws, by the analogy of magnetism, has completely failed of enabling us to calculate the results of the actions of the forces, supposed to be concerned, in any correct manner: to say nothing of the extreme complication of the properties, which it would be necessary to attribute to the simplest and minutest substances, in order to justify the original hypothesis of a polarity, existing in all the particles of light, and a directive attraction, that is, a combination of attraction and repulsion, in every reflecting or refracting substance. In the undulatory theory, we may discover some distant analogies, sufficient to give us a conception of the possibility of reconciling the facts with the theory, and perhaps even of reducing those facts to some general laws derived from it: although it will be necessary, in this intricate part of the inquiry, to proceed analytically rather than synthetically, and to rest satisfied for the present, without bringing the analysis to a termination by any means explanatory of all the phenomena. Some of the supporters of this theory may perhaps be of opinion, that its deficiencies are too strongly displayed by this attempt: but it is for them to find a more complete solution of the difficulties, if any such can be discovered.

In the case of a wave, moving on the surface of a liquid, considering the motion of the particles at some little distance below the surface, as concerned in the propagation of an undulation in a horizontal direction, we may observe that there is actually a lateral motion, throughout the liquid, in a plane of which the direction is determined by that of gravitation; but this happens because the liquid is more at liberty to extend itself on this side than on any other, the force of gravitation tending to bring it back, with a pressure of which the operation is analogous to that of clasticity; and we cannot find a parallel for this force in the motions of an elastic medium. It is indeed very easy to deduce a motion, transverse to the general direction, from the combination of two undulations proceeding from two neighbouring points, and interfering with each other, when the difference of their paths amounts to half an interval: for the result of this combination will be a regular, though a very minute vibration in a transverse direction, which will continue to take place throughout the line of the propagation of the joint motions, although certainly not with any force, that would naturally be supposed capable of producing any perceptible effects. There must even be a difference in the motions of the particles in every simply diverging undulation, in different parts of the spherical surface to which they extend: for, supposing it to originate from a vibration in a given plane, the velocity of the motion constituting the undulation will be greatest in the direction of that plane, and will disappear in a direction perpendicular to it, or rather will there become transverse to the direction of the diverging radii: and in all other parts there must be a very minute tendency to a transverse motion, on account of the difference of the velocities of the collateral direct motions, and of the compressions and dilatations which they occasion. When, also, a limited undulation is admitted into a quiescent medium, it loses some of its force by diffraction on each side, where it is unsupported by the progress of the collateral parts: and if an undulation were admitted by a number of minute parallel linear apertures or slits, or reflected from an infinite number of small wires, parallel to each other, it would still retain the impression of the incipient tendency to diffraction in all its parts, producing a modification of the motion, in a direction transverse to that of the slits or wires. It is true that all these motions and modifications of motion would be minute beyond the power of imagination, even when compared with other motions, themselves extending to a space far too minute to be immediately perceived by the senses: and this consideration may perhaps lessen the probability of the theory as a physical explanation of the facts: but it would not destroy its utility as a mathematical representation of them, provided that such a representation could be rendered general, and reducible to calculation: and even in a physical sense, if the alternative were unavoidable, it is easier to imagine the powers of perceiving minute changes to be all but infinite, than to admit the portentous complication of machinery, which must be heaped up, in order to afford a solution of the difficulties, which beset the application of the doctrine of simple projection to all the phenomena of polarisation and of colours. It is not however possible at present to complete such a mathematical theory, even on imaginary grounds; although a few further analogies between polarisation and transverse motion force themselves on our observation.

In the theory of emission, the resemblance of the phenomena of polarisation to the selection of a certain number of particles, having their axes turned in a particular direction, supposing these axes, like those of the celestial bodies, to remain always parallel, will carry us to a certain extent, in estimating the quantity of light contained in each of the two pencils, into which a beam is divided and subdivided: but it would soon appear, that, after a few modifications, this parallelism could no longer be supposed to be preserved: we should also find it impossible to assign the nature and extent of any forces, which might be capable of changing the former directions of the axes, and fixing them permanently in new ones. The distinction of a fixed, a moveable, and a partial polarisation, which has been imagined by Mr Biot, must vanish altogether, upon considering that all the effects, which he attributes to the partial polarisation, are observable in experiments like those of Mr Knox, in which there is confessedly no polarisation at all.

If we assume as a mathematical postulate, in the undulatory theory, without attempting to demonstrate its physical foundation, that a transverse motion may be propagated in a direct line, we may derive from this assumption a tolerable illustration of the subdivision of polarised light by reflection in an oblique plane. Supposing polarisation to depend on a transverse motion in the given plane, when a ray completely polarised is subjected to simple reflection in a different plane, which is destitute of any polarising action, and may therefore be called a neutral reflection, the polar motion may be conceived to be reflected, as any other motion would be reflected at a perfectly smooth surface, the new plane of the motion being always the image of the former plane: and the effect of refraction will be nearly of a similar nature. But when the surface exhibits a new polarising influence, and the beams of light are divided by it into two portions, the intensity of each may be calculated, by supposing the polar motion to be resolved instead of being reflected, the simple velocities of the two portions being as the cosines of the angles formed by the new planes of motion with the old, and the energies, which are the true measure of the intensity, as the squares of the sines. We are thus insensibly led to confound the intensity of the supposed polar motion, with that of the reflected light itself; since it was observed by Malus, that the relative intensity of the two portions, into which light is divided under such circumstances, is indicated by the proportion of the squares of the cosine and sine of the inclination of the planes of polarisation. The imaginary transverse motion might also necessarily be alternate, partly from the nature of a continuous medium, and partly from the observed fact, that there is no distinction between the polarisations, produced by causes precisely opposed to each other, in the same plane.

Why light should or should not be reflected at certain surfaces, when it has been previously polarised, cannot, even with the greatest latitude of hypothesis, be very satisfactorily explained, but it is remarkable that the transmission is never wholly destroyed, or even weakened in any considerable proportion. We might, indeed, assign a reason for the occurrence of a partial reflection or a total transmission in the constitution of the surface concerned: since every abrupt change of density must necessarily produce a partial reflection, while a gradual transition by insensible steps must transmit each impulse with undiminished energy, and without any reflection of finite intensity, as in the well known case of a collision, supposed to be performed with the interposition of an infinite number of balls of all possible intermediate magnitudes. If, therefore, we could find any modification of light, which could cause it to be transmitted from one medium to another in a more or less abrupt manner, we should thus be able to discover a cause of a variation of the intensity of the partial reflection: and this seems to be the nearest approach, that we can at present make, to an explanation of the phenomenon, according to the undulatory theory.

Art. 6. (Sect. V.) The equal intensity of the colours of thin plates, seen by reflection and by transmission, is a fact which would not have been expected from the immediate application of the law of interference, and which seems, therefore, at first sight to militate against its general adoption. But this is only one of the many modifications of the law, which are the immediate consequences of its connexion with the undulatory theory; and it may be demonstrated, from the analogy of a series of elastic bodies, that no material difference in the intensity of the two kinds of colours ought to be expected in such circumstances. The intensity of a ray of light must always be considered as proportional to the energy or impetus of the elementary motions of the particles concerned, which varies as the square of the velocity, and not simply as the velocity itself: for if the velocity were made the measure of intensity, there would be an actual gain of joint intensity, whenever a ray is divided by partial reflection: since it follows from the laws of the motion of the centre of inertia, that when a smaller body strikes a larger, not the sum, but the difference of the separate momenta, will remain unchanged by the collision, while the sum of the energies remains constant in all circumstances; the square of a negative quantity being equal to that of the same quantity taken positively. Thus, supposing an elastic ball, 1, to strike another of which the mass is r, with the velocity 1, the velocity of the transmitted impulse will be $\frac{2}{r+1}$, and that of the reflected, $\frac{2}{r+1}-1=-\frac{r-1}{r+1}$, the sum of the momenta in the opposite directions being $\frac{3r-1}{r+1}$, instead of 1, the original momentum; but the energies, expressed by the products of the masses into the squares of the velocities will be $\frac{4r}{(r+1)^2}$, and $\left(\frac{r-1}{r+1}\right)^2$ respectively; and the sum of these is $\left(\frac{r+1}{r+1}\right)=1$. Now, when an impulse arrives at the

last of a series of larger particles, and is reflected in an inverted form, if we substitute $\frac{1}{r}$ for r, the energies will be in the proportion of $\frac{4}{r}$, and $\left(\frac{1}{r}-1\right)^2$, or of $4r$ and $(1-r)^2$, which is the same as the former: so that, according to this analogy, the subdivision of the light at the second surface of a plate must be in the same proportion as at the first. We may call this proportion that of m^2 to n^2, m^2+n^2 being equal to 1: we have then n^2 for the energy of the first partial reflection, m^2n^2 for the second; and m^2n^4 for the third: for the first transmission, into the substance, m^2; for the second, out of it, m^4; for the third, after an intermediate reflection, m^4n^2; and for the fourth, after two reflections, m^4n^4; and the elementary velocities in either medium, compared among themselves, will be as the square roots of the respective energies. But it may be proved that, in all collisions of two moving bodies, each of the motions produces its effect on the velocities after impulse, independently of the other: so that the changes introduced, in consequence of the motion of one of the bodies concerned, are the same as it would have occasioned, if the other had been at rest; and consequently, if two undulations interfere in any manner, the joint velocities of the particles must always be expressed by the addition or subtraction of the separate velocities belonging to the respective undulations. When, therefore, the beam first partially reflected, of which the elementary velocity is expressed by n, interferes with the beam transmitted back, after reflection at the second surface, with the velocity m^2n, the joint velocity, in the case of the perfect agreement of the motions, will be $n+m^2n$, and in case of their disagreement, $n-m^2n$; the energies being $(n+m^2n)^2$ and $(n-m^2n)^2$; the difference, which is the true measure of the effect of the interference, being $4m^2n^2$, that is, four times the product of the respective velocities. But when the light simply transmitted at the second surface, with the velocity m^2, interferes with the light transmitted after two reflections, with the velocity m^2n^2, the quadruple product becomes $4m^4n^2$, only differing from the former in the ratio of m^2 to 1, which is that of the intensity of the light transmitted by the single surface to the intensity of the incident light, the difference being much too slight to be directly perceived by the eye; so that this result may be considered as agreeing perfectly with Mr Arago's observation.

We may also obtain, from the analogy with the effects of collision, an illustration of the intensity of the partial reflection in different circumstances; although it is not easy to say what ought to be the precise value of r in the comparison. If we imagined the two mediums to differ only in density, while their elasticity remained equal, which is the simplest supposition, the density must be conceived to vary as the square of the velocity appropriate to the medium: but the value of r, thus determined, makes the partial reflection in general much too intense, and it becomes necessary to suppose it weakened by the intervention of a stratum of intermediate density, such as there is every reason to attribute to the surfaces of material surfaces in general, from the considerations stated in the article COHESION of this *Supplement*. However this may be, we shall in general approach sufficiently near to a representation of the phenomenon, by taking the mass r in the simple proportion of the refractive density: thus, in the case of water, making $r=\frac{4}{3}$, we have for the energy of the first partial reflection $\left(\frac{r-1}{r+1}\right)^2=\frac{1}{49}=.0204$, while the result of Bouguer's experiments is .018; and the agreement is as accurate as could have been expected, even if the whole calculation had not been an imaginary structure. In the case of glass, the difference is somewhat greater; and it is natural to expect a greater loss of light from a want of perfect polish in the surface: for, taking $r=\frac{3}{2}$, we have $n^2=.040$, and Bouguer found the reflection only .025. The surface of mercury reflected nearly .60; whence r should be about 8: whether the index of the refractive density can be so great as this, we have no precise mode of determining; but there seems to be something in the nature of metallic reflection, not wholly dependent on the density: thus it may be observed, that potassium has a very brilliant appearance, though its specific gravity is very low; at the same time, its great combustibility might give it a much higher rank among refractive substances, than could otherwise have been expected from its actual density.

Art. 7. (Sect. XIII.) Although the ingenuity of man has not yet been able to devise any thing like a satisfactory reason for the reflection of a polarised ray in one case, and its transmission in another: yet several attempts have been made, with various success, to reconcile the different hypotheses of light with the other phenomena of oblique refraction. The illustrious Mr Laplace has undertaken to deduce the laws of this refraction, according to the projectile system, from the general doctrines of motion; and he has sufficiently demonstrated, that the path followed by the light is always such, as to agree with the principle of the least action, supposing the law of the velocities previously established; or in other words, that the sum of the products of the spaces described, into the respective velocities, is always the least possible. To this demonstration it has been objected, that notwithstanding the complication of its steps, it is in fact nothing more than the simple translation of the fundamental law of Huygens into another language: for it is assumed in this theory, upon obvious and intelligible grounds, that the path of light must always be such, that the time may be equal with respect to two neighbouring collateral parts of the undulation; which is the well known condition of a minimum of the whole time employed: and the time being always expressed by the space divided by the velocity, if we suppose the proportions of the velocities to be inverted, as in the two theories

respecting light, the expression of the time in the one will be identical with that of the action in the other: consequently the conditions of the propagation of light, in the Huygenian doctrine, must always imply the observation of the law of least action in the opposite hypothesis: and this general proposition Mr Laplace has taken great pains to prove, with respect to a particular instance, in which the Huygenian calculation had been found, notwithstanding Newton's doubts, to agree perfectly with the phenomena. It has also been observed, that the law of the least action is wholly inadmissible as a fundamental principle of motion: that it is completely unphilosophical to multiply unnecessarily the number of postulates or elementary laws: and that although in many cases the principle may be capable of being established as a derivative proposition, yet in order to demonstrate it, we must assume that the velocity must be the same in all directions, between the same parallel or concentric surfaces, or at any rate, must limit our reasoning by conditions, incompatible with the nature of the actions, to be considered as the foundation of the laws of extraordinary refraction.

In this single point, the undulatory theory has every possible advantage over its rival. For the difference of the velocities in different directions, no force has been assigned as a cause, in the projectile system, at all more general than the individual directions of the rays with respect to the axis. But upon the hypothesis of undulations, it has been demonstrated, without any gratuitous supposition, that every lamellar or fibrous substance must transmit every diverging impulse in the form of a spheroidal surface, supposing only the elasticity to act more powerfully in one direction than another, as it naturally must do in such circumstances. (*Quarterly Review*, No. 4.) And when we consider the experiments of Dr Brewster and Dr Seebeck, which show, that any compression or extension whatever, acting in a given direction on any transparent solid, is capable of occasioning those appearances of colour, which prove the transmission of light by an ordinary and an extraordinary refraction, we cannot help imagining, that the cause of the elliptic refraction must be of a nature more simple, than is consistent with the existence of a multiplicity of attractions, and repulsions, and polarising powers, acting in all manner of directions, with every possible variation of intensity, independently of any assignable variation of the circumstances of the light affected.

There is however another mode of considering the mechanism of elliptic refraction, which is somewhat less simple and elementary, but which affords us a further analogy to the phenomena of polarisation by reflection and transmission. If we suppose a doubling crystal to consist of a large number of very thin plates, united by a medium differing but little from them in refractive density, this pile will completely polarise the transmitted light, as Malus and Dr Brewster have shown, in a plane perpendicular to that of the incidence, even when the inclination of the surfaces is widely different from that which produces the most complete polarisation at once: and at the same time a part of the light, partially reflected by each plate, will be again reflected by the neighbouring surfaces into its original direction; nor will it be difficult to imagine that the quantity of light thus twice reflected, may, from some unknown cause, be rendered ultimately equal to that of the light simply transmitted, which, according to the laws of polarisation, will never exceed half of the original beam. Now the lengths of the paths of these two portions will not only be different, but the difference will vary according to the direction: for while the light simply transmitted proceeds to describe its path, with the uniform velocity belonging to the mean of the two mediums, combined always in a constant proportion, the light twice reflected by each plate will be retarded most of all in the direction perpendicular to the plates, as in the case of the colours of common thin plates; and in oblique directions, the number of plates, which it has to pass through in a given space, being as the cosine of the angle of incidence, and the retardation in each plate being also as the same cosine, neglecting the difference between the angles of incidence and refraction, which is supposed to be inconsiderable, the whole retardation will be as the square of the cosine of the inclination to the axis, which is the well known proportion of the difference of the diameters of a circle, and of an ellipsis approaching near in it. We thus obtain a general idea of the combination of two effects, which do not appear to be related in any other point of view, a regular oblique refraction and a distinct polarisation; further than this the comparison is by no means completely satisfactory: and the great difficulty of all, which is to assign a sufficient reason for the reflection or nonreflection of a polarised ray, will probably long remain, to mortify the vanity of an ambitious philosophy, completely unresolved by any theory. (I. S.)

CHRONICLE, Parian. See the *Encyclopædia* under this head, and Parian Chronicle in this *Supplement* for some corrections.

CINNAMON. The plant which produces the aromatic bark called cinnamon, is described under the word *Laurus*, in the article Botany of the *Encyclopædia*. The following particulars are extracted from a manuscript account of the cultivation and commerce of cinnamon, written in Ceylon in 1816, by Mr H. Marshall. The word cinnamon occurs in several passages of the English version of the *Old Testament*. Cinnamon was burnt on the funeral pile of Sylla and of Poppæa. The ancients got their cinnamon through Arabia, to which country it was brought probably from Ceylon.

In 1498, Vasco di Gama landed at Calicut, and from that time the merchandise of India, which had formerly been imported into Europe through the

Cinnamon. medium of the Venetians, took a different route, and was carried round the Cape of Good Hope by the Portuguese. The Portuguese were the first Europeans who established a factory in Ceylon. This they accomplished at Colombo, in the early part of the sixteenth century; notwithstanding the opposition of the Arabian merchants, who carried on the trade from Ceylon, and who did all in their power to prevent the establishment of the Portuguese. The Portuguese were driven from Ceylon by the Dutch in 1656, and the Dutch by the English in 1796.

Cinnamon Gardens.

The Dutch were the first who cultivated the cinnamon plant in Ceylon. They began to form plantations of cinnamon in 1765, and in 1778 Thunberg found these plantations extensive, and some of the plants or stools had already afforded bark three times. Before these plantations were formed, the Dutch were supplied with cinnamon bark from the cinnamon plants that grow spontaneously in the territory of the king of Candy, and by the sufferance of that chief. The part of the old Dutch territory between Negumbo and Matura is that which is best fitted for the cultivation of cinnamon.

Produce of cultivated Cinnamon.

Each cinnamon plant in the cinnamon gardens in Ceylon affords, on an average, four tenths of an ounce of bark every second year. But a cinnamon plant, in its most vigorous state, and carefully cultivated, produces 23 ounces of bark every second year.

Spontaneous Cinnamon Plants.

Besides the bark got from the cinnamon gardens, a considerable quantity is also collected from spontaneous plants. A great part of the interior of Ceylon is covered with trees and brushwood. Where the declivities are gentle, the cultivation of dry grain is practised. For this purpose, the trees and brushwood are cut down, the trunks and branches are burnt, and the ashes spread on the ground; and on the soil thus prepared, dry grain is sown. The roots of the trees and bushes still remain in the ground. One crop only is taken, and in a few years the ground is again covered with trees and brushwood. At the end of 15 or 20 years, the same spot is treated as before, for the purpose of yielding a crop of grain. A piece of ground cultivated in this way is called a china. Upon these chinas which have been recently cultivated, cinnamon plants of a proper age for yielding cinnamon bark are found growing spontaneously, and the bark of these cinnamon plants is collected. But the best cinnamon bark is obtained from the plants cultivated in the cinnamon gardens.

Contract with the East India Company.

By the agreement made in 1802, the English Government of Ceylon engages to supply the East India Company annually with 400,000 lb. of cinnamon, at the rate of 3s. Sterling *per* lb. If any ship is found to have more than 20 lb. of cinnamon on board, without permission from the English government of Ceylon, or from the East India Company, the ship and cargo are liable to confiscation.

That there might not be produced a greater quantity than that required for the East India Company's investment, some of the cinnamon plantations were rooted out soon after the settlement came into the possession of the English. But it was afterwards found expedient to increase the produce of cinnamon; and for that purpose the cinnamon plantations were cultivated with increased attention.

The average annual exportation of cinnamon from Ceylon, from 1804 to 1806 inclusive, was 290,018 lb.; and from 1807 to 1814 inclusive, 370,913 lb. The annual average expence was L. 14,223, or about 9d. *per* lb. The cinnamon which has not the qualities proper for the European market is rejected. Part of this rejected cinnamon is sold to merchants at about 2s. *per* lb. It is shipped for the supply of the British settlements in India. That which goes to Bombay is reexported to Jedda and Massuah. Some of it reaches England under the name of Casia.

Cinnamon ‖ Circars.

Quantity exported from Ceylon.

Average yearly quantity of cinnamon sold at the East India Company's sales, from 1803 to 1810 inclusive, - - -	318,258 lb.
which brought L. 95,825, about 6s. *per* lb.	
According to Stavorinus, the average quantity sold by the Dutch, from 1775 to 1779, was . -	370,000
which brought L. 203,500, about 11s. *per* lb.	

Canton Cinnamon.

The average of the Dutch sales from 1785 to 1791 is greater, and the price is nearly double the average English price from 1803 to 1810. The large quantity of cinnamon brought from Canton is probably the cause of the diminution in quantity, and the fall in price of the Ceylon cinnamon. The cinnamon from Canton is generally inferior in aromatic quality, but it is brought to market at a lower price than the Ceylon cinnamon. It is sold under the name of casia. It is imported into Canton from the Sooloo islands, and from Cochin-China. It does not appear that any cinnamon is produced in China.

The third quality of Ceylon cinnamon is considered equal to that brought from China, and could probably be supplied at as low a price. This quality of cinnamon might be collected in Ceylon to a great amount, and a large importation of it into the London market, sold at a moderate profit, would probably lessen the demand for Canton cinnamon.

Cinnamon grows on the Malabar coast, and was collected there in the dominion of the king of Travancore by the Dutch and the English. Of this trade, an account is given by Fra Paolo de San Bartholomeo, who resided in that country in 1776. Cinnamon is also collected in Sumatra. Bruce says, that it grows in the country between Cape Gardefan and Melinda.

Oil of Cinnamon.

In 1804, a considerable quantity of essential oil was distilled from the rejected cinnamon in Ceylon; and latterly (1816) 3000 ounces have been distilled, part of which was sent to England. But it is more profitable to sell the rejected cinnamon, than to distil the oil from it.

Casia-buds are the receptacle of the fructification of the cinnamon plant. They are imported into Europe chiefly from Canton. They might be collected abundantly in Ceylon, but this has not hitherto been done. (Y.)

CIRCARS (Northern), an extensive district of Indostan, extending about 470 miles along the coast of Coromandel, from the frontier of the Carnatic to that of Bengal. It reaches inland from 40 to 70 miles, when it is separated from the provinces of Hydrabad and Berar by a range of hills, which in the

Circars. south are low and detached from each other, but in the north rise into high mountains, impassable for horses or carriages, unless at a single point near Salourgant. The area of the whole is estimated at 17,000 square miles, of which Mr Grant (Appendix to *Fifth Report on Indian Affairs*, p. 620) supposes one-fifth to be under cultivation. This last estimate is given as purely conjectural; and considering that the tract is generally level, and that besides maintaining a large internal population, it exports grain to a great extent, it seems scarcely possible that it should not contain a much larger proportion of cultivated land. The number of inhabitants is calculated at two millions and a half, which would give nearly 150 to the square mile.

History. The Circars, after enjoying for many ages a native government, experienced the weight of Mahometan power, when, in 1541, the sovereign of the empire of Beder, conquered first Condapilly, and afterwards Guntoor, with the whole district of Masulipatam. The subjection, however, was so imperfect, that, in 1571, the country was to be conquered anew. It became then attached to the dominion of Hydrabad, and along with it fell, in 1687, under the wide spread empire of Aurungzebe. That conqueror, however, absorbed in distant and more splendid objects of ambition, appears to have been satisfied with little more than a formal submission. The Circars never fully felt the yoke, till, on the breaking up of the Mogul empire, they became a portion of the kingdom founded at Hydrabad, by Nizam-ul-Moolk. These territories formed to the Nizam a more important object than they had done to the Mogul. He accordingly occupied them with a military force, and took vigorous measures for collecting the revenue. After the death of Nizam-ul-Moolk, his third son, Salabat Jung, was enabled, through the aid of the French, to obtain the sovereignty of the Circars; but when Masulipatam, in 1759, yielded to the British arms, Salabat Jung, deprived of French support, was unable to maintain his authority, and these territories reverted to the reigning Nizam. Soon after Lord Clive threw upon them an ambitious eye; and, availing himself of the obsolete claim of the Mogul, obtained from that sovereign a grant of the Circars, which, in the following year, the Nizam found it necessary to confirm. Only four of the five, however, came into the immediate occupation of the British; the fifth, Guntoor, being retained for life by Bazalet Jung, a son of the Nizam, who held it in Jaghire, so that it did not devolve to the Company till the year 1788.

Under all these revolutions, the interior administration of the Circars remained unaltered. Here, and over the greater part of the south of India, the village system has been long fully established. A village, politically considered, includes not only the inhabited spot, but a certain surrounding district, from which its subsistence is drawn. In each village, all employments, except the simple one of cultivating the ground, are performed by public servants, who receive, as the salary of their office, a certain portion of land, besides some small perquisites at the time of harvest. Of these functionaries the most eminent are, the potail, or chief, the talia and totie, two species of police officers; the boundary man; the superintendant of the water courses; the brahmin; the schoolmaster; the astrologer; the smith and carpenter; the poet; the musician; and the dancing girl. Under this simple form, most of these villages have, for a long series of ages, preserved not only their institutions, but even their name unchanged; they have seen, uninjured, all the storms of revolution pass over their heads. When revenue is to be raised, or even exactions levied, it is found most convenient to make the agreement with several of the leading men in the village; the sum being then collected by an arrangement among the inhabitants themselves.

This constitution prevails chiefly in the plains. The hilly districts are possessed by Zemindars, who let their lands by a sort of feudal tenure, on condition of military service. These Zemindars, unless when kept in strict subjection by a foreign power, hold in their hands the chief sway over the Circars. About the time when the province came into the possession of the British, they were supposed to have on foot no less than 41,000 troops. The Company appointed provincial chiefs and councils; but the power of the Zemindars continued nearly unbroken till 1794, when punishment was inflicted on the great Zemindar of Vizianagrim, who had oppressed and expelled many of the inferior chiefs. In 1802 and 1804, the salutary system of a permanent settlement of the territorial revenue was introduced. The administration, however, has not yet been placed on that regular and systematic footing, from which Bengal has derived such important advantages.

Climate and Productions. The climate of these provinces is, by the influence of the sea breezes, rendered cooler than most other regions placed under the same latitude. At the season, however, which immediately succeeds the vernal equinox, the heat becomes exceedingly intense, particularly in some of the sandy tracts near the sea coast. In the hilly districts, filled with marsh and jungle, the damp and heat combined generate a pestilential air, which gives rise to a dangerous malady, called the hill fever. The soil along the shore is sandy, but improves as it approaches the hills, when, at a certain height, cultivation gives place to woods and jungle. The intermediate tracts are well watered, and, though they yield only one crop in the year, yet that one is abundant. Rice and other grains are not only produced in quantity sufficient for internal consumption, but are exported to such an extent, as to make the Circars, during the northern monsoon, be considered as the granary of the Carnatic. Fruits, greens, and roots are raised with difficulty, particularly in the southern districts, owing, it is supposed, to the influence of the sea air. Sugar and cotton are not so plentiful as to render the province independent of foreign supply; but bay salt and tobacco are, to a certain extent, objects of exportation. An article capable of being turned to the most valuable account, presents itself in the noble forests of teak timber which grow upon the frontier mountains. The animal productions are confined chiefly to the useful species of sheep and horned cattle, which are produced in great abundance.

Manufactures. The Circars are not less eminent as a manufacturing, than as an agricultural district. The cotton fabrics which form its staple, are chiefly of two kinds.

Circassia.

The first is fine long cloth, which forms the basis of the finest calicoes. This exquisite manufacture is chiefly carried on in the island of Nagur, formed by the two large branches into which the Godavery divides itself before entering the sea. The security here enjoyed from the ravages of war has allowed this valuable branch of industry to attain its present degree of perfection. This cloth forms the sole basis of the trade to Europe; and the annual exports thither are supposed, by Mr Grant, not to fall short in value of thirty lacks of rupees. The next fabric consists of coarser cloths, dyed with the chaya root, the madder of India, which grows in perfection in the sands annually overflowed by the Kistna. This manufacture is much more widely diffused, and the demand for it is immense, both in the interior, and in the regions to the east. The muslins of Cicacole, the woollen carpets of Ellore, and the silks of Berhampoor, form curious and elegant fabrics, but are produced in such small quantity, as to be of little commercial importance.

Commerce.

The foreign trade of the Circars is chiefly carried on by the channel of Madras, to which the natives, in their small craft, convey its produce. The valuable article of piece goods, however, is chiefly exported in larger vessels from Masulipatam. In 1805, the exports to Madras amounted in grain to 17,64,040 sicca rupees; in piece goods to 5,59,146; and a variety of minor articles raised the total amount to 25,60,564 rupees. The imports, consisting of numerous small articles, did not exceed 5,91,144 rupees.

Number of the Circars.

The Circars are commonly reckoned five in number, divided from each other by a succession of considerable rivers which cross the territory and fall into the sea. Cicacole, the most northerly and most extensive, is separated from the rest by the great stream of Godavery, which, after a course of upwards of 700 miles, falls here into the Bay of Bengal. Rajamundry is situated around and within the branches of the Godavery; Ellore and Condapilly occupy the space as far as the Kistna or Krishna; while Guntoor fills the interval between the Kistna and the southern boundary of the Circars. Masulipatam and the surrounding district have been recently considered as forming a sixth Circar.

Revenue.

The following estimate formed by Mr Grant, of the gross revenue, in Madras pagodas of 4 rupees each, drawn, in 1783, from the different Circars, will give a tolerable idea, at least of their relative value;

Guntoor, . .	3,51,000
Masulipatam, . .	1,44,500
Condapilly, . .	3,18,000
Ellore, . .	3,41,143
Rajamundry, . .	5,04,052
Cicacole, . .	9,92,427½
	26,51,122½

The Circars are chiefly known to Europeans by their sea-ports, which, however, are neither numerous nor of convenient approach. The most important by much is Masulipatam, affording the only point on the coast of Coromandel at which vessels can anchor without experiencing the inconvenience of a heavy surf. The town is very extensive and populous, and is defended by a strong fort, viewed as the maritime bulwark of the Circars. The French had a factory here from 1669; and in 1751, they obtained possession of the town and fort, which they greatly strengthened. In 1759, the British, under Colonel Ford, took the fort by storm; Masulipatam was soon after ceded to them, and has continued in their possession ever since. Though no longer, as formerly, the principal place on the coast of Coromandel, it is still the theatre of an extensive commerce. Besides Madras, it trades on a great scale with Calcutta and with Bassora, on the Persian Gulf. The trade with Calcutta consists chiefly of imports, as rice, raw silk, shawls, rum, and sugar. That with Bassora is supported almost entirely by the export of piece goods, particularly chintzes, which, though inferior to those of Europe, are celebrated in the east, and an object of extensive demand throughout the Persian empire. The exports to Bassora in 1811-12 amounted to 1,299,000 rupees, while the total exports did not exceed 2,136,000. See *Fifth Report on Indian affairs*. (B.)

Circars || Circassia.

Situation and Extent.

CIRCASSIA, a country of Asia, situated on the northern declivity of that great mountain range which, under the appellation of Caucasus, fills the space from the Caspian to the Black Sea. This territory extends across from sea to sea, and northward to the rivers Terek and Cuban. Nothing can be more striking than the approach to this region, when from the *steppe*, or immense level plain to the north, is seen, abruptly rising, the vast mass of the Caucasian mountains. Four distinct groups are clad in perpetual snow, and, above all, towers the stupendous Elbrus, which rivals Mont Blanc in magnitude. The lower intervening range, called the Black Mountains, is very precipitous, and has the appearance of a regular wall. These mountains are not supposed to exceed half the elevation of the Elbrus. At the foot of these stupendous ranges lie a number of fertile and beautiful vallies, which not only feed numerous flocks and herds, but yield, in abundance, maize and millet, the grains chiefly cultivated in this part of the world.

Different Tribes of Inhabitants.

The people by whom this picturesque region is inhabited, present moral and physical features not less remarkable than those of the spot which they occupy. The name of Circassians is a corruption of the Russian term of Tcherkess or Tcherkessians. Neither of these names, however, is known or recognized within the region itself; and, indeed, there is no foundation for our idea of the Circassian territory being inhabited by any single nation. It is filled with a number of small, separate, and hostile tribes, many of whom do not even understand each other's language. Among the most remarkable are the Kabardines, Great, and Little; the Abasses, the Kisti, the Ossetes, with many others, whose names it were needless to enumerate. As they all, however, agree in their general aspect, and are included by the Russians under one name, our object and limits will rather lead us to delineate their common features, than to enter into a tedious delineation of such as are peculiar to each.

Of all the nominal vassals of the Russian empire, the Circassians are in the most imperfect state of subjection. In the archives of the Czars, indeed,

Circassia. acknowledgments of dependence are found as early as the commencement of the present century; but these were granted only in return for temporary aid against attacks from the Tartars of the Crimea, and never led to any farther consequences. Even now, when Russia has established herself in such force on the Caspian, she has not succeeded in reducing these tribes to any form of regular subjection. They own themselves, indeed, her vassals, but they neither pay tribute, nor perform any species of military service. On the contrary, they make regular incursions into the Russian territory, from which they carry off booty, particularly cattle, in large quantities. To check these inroads, indeed, a line has been drawn along the northern boundary of the Terek and the Cuban; it has been strengthened by the fortresses of Modok and Georgiewsk; and the severest punishments have been denounced against such of the Circassians as should transgress this limit. These threats, however, not being put into rigorous execution, the offence continues to be annually repeated. Potemkin endeavoured to conciliate the people by granting titles and presents, and even by raising some of them to the rank of Russian princes; but such favours were, by those proud chiefs, only viewed as new proofs of their invincible prowess, and they became but the more daring in their depredations. At present it is impossible to go with safety even a few miles beyond the frontier fortresses. The Circassians may, indeed, complain on their side of encroachment; since, prior to the present extension of Russian power, they had extended their sway over the greater part of the level country, which extends northward as far the Kuma.

Government and Political State. From the causes now noticed, the Circassians, in the face of this great and ambitious power, have preserved entire their political independence, with all the habits of their domestic and military life. Circassia presents now nearly the same picture which was exhibited by Europe during the twelfth century. No general authority exists: the power is entirely in the hands of the chiefs, each of whom holds sway over a certain number of vassals. The pride of birth prevails to a degree scarcely equalled by any other nation. The Circassians may be generally divided into four classes. 1. The Princes, who exercise the sovereign authority, each within his own limits. 2. The Uzdens or nobles, who, with their vassals, attend the prince in war or plundering excursions, but, in the common train of affairs, are nearly independent of him. 3. The Freedmen, either of the princes or uzden, who, by manumission, are considered as having attained to the rank of uzden, but are still bound to their former master, so far as relates to military service. 4. The Vassals, who are held by the uzden in the most complete subjection, and are employed either in agriculture or in menial offices. Over this degraded class, the masters possess the power both of life and death, and of selling them into slavery, which, however, is said by Pallas to be rarely exercised. A friend of ours saw a Circassian prince bring into Ekaterinodar several slaves to sell, with their eyes bandaged, and a leathern thong covering their mouth. He professed to have taken them in war; but the circumstances induced a strong suspicion that they were his own vassals, and that these precautions were adopted to prevent a discovery. It thus appears, however, that he was ashamed of selling his own people.

Beauty of the Circassians. The Circassians are eminently distinguished by their physical qualities; among which beauty of form, so rare among barbarous tribes, holds a conspicuous place. The men are tall, of a thin but very athletic shape; they have expressive features, a haughty and martial air. The females possess a peculiar elegance of form and delicacy of complexion, which has long been celebrated throughout Europe, and which the admirable productions of Mr Allan's pencil have lately rendered familiar to the eye of persons of taste in this country. This Scottish artist resided for some time among the Circassian tribes. Females in Circassia appear to be less immured than in most eastern countries; at the same time they are equally exempted from any severe labour, and their face is carefully shaded from the action of the sun. The most studious care is taken to preserve the elegance of their form. Their food, when young, consists entirely of milk and pastry, of which too they receive only a limited allowance. They never go from home without wearing a species of wooden clogs to preserve the feet clean and dry, and the hands are carefully covered with gloves. One of the most remarkable appendages is a broad leathern girdle, which, at the age of ten or eleven, is fastened with silver clasps, and is never taken off till after marriage, when the bridegroom, with a sharp instrument, cuts this gordian knot, often not without danger. The face is painted only by those who bear an equivocal character.

Manners, Customs, and Occupations. The pride of this people is manifested by the contempt with which they treat those domestic ties and affections, which are most cherished by the rest of mankind. The husband never sees his wife, unless in the most mysterious privacy; he considers it as an insult that any one should ask for her health, or even name her in his presence. The arrangements with regard to children are still more extraordinary. At the age of three or four, they are separated from their parents; the care of rearing them is undertaken by an uzden, of the same rank with the father, but who, from some tie of dependence or obligation, is induced to undertake this office. On him devolves the whole charge of their support, education, and instruction, nor does the parent ever see them till they are presented to him at full age, and completely accomplished in all manly exercises. The foster-father depends for reward chiefly on the gratitude of his pupil, who naturally regards him with at least equal attachment as his natural father. The female children are in like manner placed under the care of the uzden, who, after completing their education, provides for them a suitable husband; and they are never seen by the father till after marriage. In a country where such paramount importance is attached to birth, unequal marriages are not only held in abhorrence, but are entirely unknown. The prince invariably marries the daughter of a prince, the uzden that of an uzden. Polygamy, though permitted by law, is not carried to any great extent, and the female sex appear to occupy a higher place in society, than in most of the other Asiatic countries.

Circassia.

The Circassian nobles spend their time almost exclusively in hunting, feasting, and in expeditions for war and plunder. Their chief pride is their arms, on which they often expend large sums; indeed the value of a suit of complete armour for a nobleman of high rank is estimated at 2000 rubles. Those chiefly used are a bow and quiver, which are fastened round the waist and hang down on the thigh; a musket and pistols, ornamented with silver, sometimes even with pearls and precious stones; a helmet and arm-plates of polished steel; and, above all, a coat of mail, composed of polished steel rings. This last is often of such excellent quality, that the discharge of a loaded pistol will not penetrate it. The Circassian never moves abroad without these accoutrements; and a great part of his time is spent in keeping them perfectly bright and clean. The next and nearly equal object of pride is their horses. Beauty is here attempted to be combined with fleetness, strength, and the capacity of enduring fatigue; qualities extremely necessary in the light expeditions in which they are habitually engaged. Every great man has a race of horses belonging to himself, the genealogy of which is conceived to be only second in importance to that of the family. At the birth of a foal, a mark, indicating its pedigree, is burnt upon the thigh, to alter or falsify which mark is considered as a capital offence.

Among the passions, that of revenge prevails, as in all barbarous societies, where no regular forms of justice being established, each individual must vindicate his own cause. The rights of hospitality are held equally sacred, as among all other nations in a similar state of society. A Circassian chief, having received a stranger under his roof, or given him a promise of protection, will defend him even at the hazard of his own life. The firmest pledge which can be given is, that of allowing him to suck a mouthful of milk from the breast of the wife, after which he is considered as one of the family, and his wrongs or death to be avenged to the same extent as if he had really belonged to it.

About the middle of the last century, the Circassians were induced to embrace the religion of Mahomet. They are far, however, from being rigorous votaries, though the precepts of the Koran have induced some alteration on their former habits. They abstain from brandy, tobacco, and hog's flesh; they marry earlier, and polygamy has become somewhat more common.

Agricultural industry has made only a small progress among the Circassians. They raise chiefly millet, with a small proportion of barley and maize; the first-mentioned grain supplies them with bread and with a fermented liquor; and in case of necessity, is given to their horses. Their only manure is formed by burning the herbage upon the land which they mean to sow. After raising crops for two or three years on the same ground, till it is exhausted, they abandon it, and break up another spot. The animals chiefly reared are sheep, which are valuable, though not equal to those of the Calmucks. Oxen are used chiefly for the plough, or for draught. From the vicinity of hostile tribes, it is seldom safe to carry on even the common operations of husbandry. Men are often seen driving the plough, "clad in complete steel," and ready at the slightest signal to fly to arms. The rearing of bees is a considerable article of industry, and some possess no fewer than 300 hives.

Circassia || Cirripedes.

It is difficult to ascertain the precise amount of the population of the Circassian tribes. Pallas supposes the number capable of bearing arms to be, of uzdens 1500, and of their vassals 10,000, but this estimate can include only a few of the tribes. He conceives that these troops, if they could be induced to submit to regular discipline, and to enlist in the Russian armies, would form the best light cavalry in the world.

(To the information derived from the *Travels* of Pallas and Klaproth, we have been enabled to add that of an intelligent friend, who penetrated into Circassia, and resided for some time among these tribes. (B.)

CIRRIPEDES, from *cirrus* and *pes*, signifying curled legs, a class of animals comprehending the *barnacles* and *acorn-shells* of English naturalists. Derivation.

Their nervous system consists of a series of ganglia, connected longitudinally by a double nervous cord. Characters.

They have a heart and circulating vessels.

The organs of respiration are a sort of branchiæ attached to the base of the legs.

The legs are twelve in number, and are terminated by many-jointed compressed appendices, which in the five anterior pairs are much elongated and ciliated beneath.

Their head is not distinct from the body, and there are no distinct organs of vision; the mouth consists of an upper lip; a pair of mandibles; a pair of maxillæ, each of which is furnished with a fleshy kind of palpus; and a lower lip, evidently formed by the union of the exterior maxillæ.

The intestinal canal is simple, and not contorted or furnished with cœca; it terminates at the base of a long proboscis-like tube. The stomach is often enlarged, and furnished with appendices.

Their organs of generation terminate at the extremity of the proboscis-like tube mentioned above.

They are hermaphrodite and oviparous.

Their food is unknown.

Many of the genera are well defined in the works of the older naturalists; but they have not been adopted by the moderns. History.

Linné arranged all the CIRRIPEDES under the generic name *Lepas* (a term applied to the *limpet* by the ancients), and named the animal *Triton*.

The great divisions of these animals are very obvious, and have been distinguished in common language, as well as by several authors, who named them *Lepas* and *Balanus*.

Lamarck, in 1812, first established the CIRRIPEDES as a distinct class, which has been adopted by Cuvier and Blainville, who consider it to constitute a distinct subtype of molluscous animals.

We regard them as belonging to the type *annulosa*, since they agree with those animals in every point of essential structure.

John Hunter was well acquainted with their organs of respiration, digestion, and generation, as may be learnt from an inspection of the preparations of those parts, preserved in his superb collection of comparative anatomy.

Poli, Cuvier, and Home, have likewise treated on the structure of the CIRRIPEDES.

Cirripedes.

CLASSIFICATION.

Order	Family			GENERA.
Order 1. CAMPYLOSOMATA. Base of the body tendinous and flexible: upper part with shelly plates; the legs passing through a slit in the anterior part.	Fam. I. CLYTIDII. Upper part of the body not much compressed, membranaceous, with very small shelly or corneous plates.	Summit of the body with two cylindric hollow processes.		1. OTION.
		Summit of the body simple.		2. CINERAS.
	Fam. II. POLICIPIDII. Upper part of the body very much compressed, and covered with shelly plates.	Five in number: base naked.		3. PENTALASMIS.
		Thirteen in number: base with hairy wrinkles, the interstices hairy.		4. SCALPELLUM.
		Five large and many small: base with shelly scales.		5. POLLICIPES.
Order II. ACAMTOSOMATA. Whole body surrounded by a shell of one or more parts. Legs passing out through the operculum which closes the upper part of the shell.	Fam. I. CORONULIDII. Operculum fleshy and protuberant: Shell sex-partite, with its base open.	Shell subcylindric, narrower at its base: operculum protected by four large equal-sized shelly valves.		6. TUBICINELLA.
		Shell with its base much wider than its apex.	Lips of operculum, very prominent, with two large shelly valves before, and one small one on each side of the legs.	7. CORONULA.
			Operculum protected by four large equal-sized shelly valves.	8. CHELONOBIA.
	Fam. II. BALANIDII. Operculum compressed, bivalve, and shelly: base closed by shelly matter.	Base cup-shaped or infundibuliform.	Shell undivided: valves of operculum bipartite.	9. PYRGOMA.
			Shell four-partite: valves of operculum undivided.	10. CREUSIA.
			Shell sex-partite: valves of operculum bipartite.	11. ACASTA
		Base of the form of the substance to which it adheres.	Shell sex-partite: valves of operculum bipartite.	12. BALANUS.
			Shell four-partite: valves of operculum bipartite.	13. CONIA.
			Shell four-partite: valves of operculum undivided.	14. CLISIA.

Order I. CAMPYLOSOMATA.

LEPAS, *Linné*, *Pennant*, *Poli*, *Montagu*, &c.
ANATIFA, *Lamarck*, *Cuvier*, &c.

Base of the body produced into a tendinous, flexible peduncle, which is composed of two coats, which pass downwards from the upper part. The interior coat is lined by longitudinal muscular fibres, and the cavity

Cirripedes. is filled by cellular matter, one side of which is traversed by a longitudinal cylindric vessel. The base of the peduncle generally spreads a little, and is closed over by the tunics.

The upper part of the body is covered by three coats; the outer one is hardest, and has generally shelly matter deposited on it. The interior coat does not pass down over the peduncle, but is confined to the upper part, and surrounds the automatic organs, and the legs, which pass out through a longitudinal slit on the anterior side of the body.

Family I. CLYTIDII.

Gen. CONCHODERMA, *Olfers.*

Upper part of the body not much compressed; the scales small; two on each side below the legs; two on the summit, and one behind.

Gen. 1. OTION, *Leach.* AURITELLA, *Blainville MSS.*

Upper part of the body abruptly clavate with two cylindrical fleshy processes on the summit.

Sp. 1. *Blainvillii.* All the scales shelly; those on the summit very small, linear; hinder one very minute.

Lepas cornuta. *Montagu, Trans. Linn. Soc.* xi. 179. t. 12. f. 1. Plate LVII.

A single specimen was found in the bottom of a transport that was stranded on the coast of Devon. The colour, whilst living, was whitish, spotted and streaked with brownish purple.

It seems to be distinct from the Lepas leporina, *Poli*, tab. vi. f. 21.

Sp. 2. *Cuvieri.* Scales beneath the legs shelly; other scales corneous.

Lepas aurita. *Cuvier, Mem. du Mus.* ii. pl. 5. f. 12.

Mr Comyns sent us a specimen that was taken on the Dawlish coast in Devon, where it was most probably brought on the bottom of a ship.

Gen. 2. CINERAS. Upper part of the body gradually clavate, with the summit simple.

Sp. 1. *Vittata.* Pale bluish purple, with three pale bluish purple stripes on each side of the body.

Lepas membranacea. *Mont. Trans. Linn. Soc.* xi. 182. t. 12. f. 2. Plate LVII.

This species has been taken on the southern coast of Devon by Mr Gibbs, and by C. Loscombe, Esq. of Exmouth. We suspect, however, that it was introduced into our seas by foreign vessels, as they are not unfrequently found adhering to the bottoms of transports and merchant vessels. It differs from Lepas coriacea, *Poli*, Tab. vi. f. 20., in the form of the scales beneath the legs.

We have seen two other species of *cineras*, one adhering to a *hydrus* in the collection of John Hunter, the other in the collection of animals formed in the expedition to Congo, by Mr J. Cranch.

Family II. POLICIPEDIDII.

Upper part of the body very much compressed, and covered entirely by shelly plates.

Gen. 3. PENTALASMIS, *Hill.*

Upper part of the body with five scales; lower ones very large; upper ones elongate, acuminated behind; hinder ones linear curved; peduncle naked.

* *Hinder scale gradually curved; peduncle long.*

This division comprehends *Lepas anatifera* of Linné, and several species that have been confounded with it.

** *Hinder scale gradually curved; peduncle very short.*

Pentalasmis sulcata, Plate LVII. *Lepas anserifera* Poli, *Lepas sulcata* Montagu; a species common on the southern coast of Devon adhering to cuttle-bone. *Lepas muricata* Poli, tab. vi. f. 23-24. together with several sulcated species, which generally attach themselves to porous bodies, belong to this section.

*** *Hinder scale angulated; peduncle very short.*

Lepas fascicularis with a very diaphanous shell, is the only species of this section that we have observed.

GEN. 4. SCALPELLUM.

Upper part of the body with thirteen scales; the hinder one linear; the upper ones semicircular; the five lower ones on each side (occupying the place held by the two lower ones in Pentalasmis) small; peduncle with corneous wrinkles, the interstices hairy.

Sp. 1. *Vulgare.* Hinder scale carinated and subangulated. Plate LVII.

Lepas scalpellum, *Linné.*

Inhabits the Mediterranean and British Seas, adhering to coralline substances, and to the tubes of marine vermes.

Gen. 5. POLLICIPES, *Hill.*

Upper part of the body with five large scales, and several smaller ones at their base; upper scales, and that on each side below the legs largest; hinder one acuminated above; peduncle scaly; scales testaceous.

Sp. 1. *Cornucopia.* Peduncle imbricated with scales; the scales pointing upwards and rounded at their extremities; scales of the upper part of the body smooth and whitish.

Lepas pollicipes of authors. Plate LVII.

This species is said to inhabit the Norwegian Seas. It has been taken in the Firth of Forth, near Leith, and was probably brought there attached to the bottom of a ship.

Sp. 2. *Smythii.* Peduncle, with irregular scales; the interstices membranaceous; scales of the upper part of the body smooth; in the old state antiquated.

Inhabits Teneriffe, where it was discovered by the late Professor Smyth of Christiania, who gave us a large groupe of them.

Sp. 3. *Tomentosus.* The whole body tomentose. Plate LVII.

The locality of this species, which is preserved in the British Museum, is unknown.

Lepas mitella, Linné, probably belongs to the genus POLLICIPES.

Order II. ACAMPTOSOMATA.

Body surrounded by a shell, composed of one or more parts, which are connected by sutures; upper part open and closed by a fleshy or bivalve testaceous operculum, through which the legs pass out.

Family I. CORONULIDII.

Operculum fleshy and prominent. Shell sex-partite, open below.

The animals of this family attach themselves to the bodies of whales and turtles.

Gen. 6. TUBICINELLA, *Lamarck.*

Shell cylindrical, like a windpipe, narrower at its base. Four large equal shelly plates arranged round the operculum.

Sp. 1. *Lamarckii.*

CIRRIPEDES.

Order CAMPYLOSOMATA.

Cineras vittata

Otion Cuvieri

Otion Blainvillii

alpellum vulgare

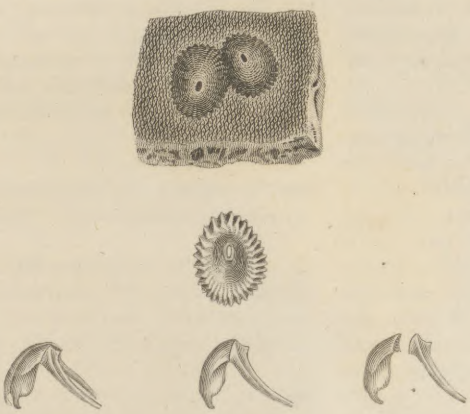
Pollicipes villosus

Pollicipes Cornucopia

Pentalasmis sulcata

Order ACAMPTOSOMATA

Tubicinella Lamarckii



Pyrgoma cancellata

Balanus Cranchii

Creusia spinulosa

Acasta Montagui

Sn y del.

Published by A.Constable & Co.Edin.r 1817.

Milton sculp.

Cirripedes.

Tubicinella trachealis, *Lamarck*.
Plate LVII.

Gen. 7. Coronula. *Lamarck*.

Shell subcylindrical, or depressed subconic; base much wider than the apex: lips of operculum very prominent, with two large shelly valves before and one small one on each side of the legs.

Sp. 1. *Diadema*. Lepas diadema of authors.

Gen. 8. Chelonobia.

Shell depressed, with its base much wider than its apex; operculum protected by four large equal valves.

Sp. 1. *Savignii*. Balanus rotudinarius of authors.

Inhabits turtles.

Family II. Balanidii.

Operculum testaceous, compressed, bivalve. Base of shell flat or concave.

A. *Base cup-shaped or infundibuliform.*

Gen. 9. Pyrgoma, *Savigny MSS.*

Shell undivided. Valves of the operculum bipartite. Base infundibuliform.

The base of the shells of this genus is imbedded in the harder species of coral.

Sp. 1. *Cancellata*. Shell with elevated radiating ribs; interstices cancellated; cancelli and ribs frosted.

Plate LVII. represents two attached to coral, one reversed, and three figures of the operculum; the first complete, the second of one valve, the third of one of the valves separated.

The locality of this species is unknown. J.-C. Savigny sent us another species, which he discovered in the Red Sea; and we have observed a third in the collection of Mr Sowerby.

Gen. 10. Creusia.

Shell quadripartite; parts equal. Valves of the operculum unipartite. Base infundibuliform.

This genus is likewise parasitical, and is found attached to coral, in which its base is imbedded.

Sp. 1. *Spinulosa*. Upper parts of the shell with radiating elevated ribs; ribs spinulose; space between the parts of the shell without ribs.

Plate LVII.

Gen. 11. Acasta.

Shell sexpartite; two parts small, four large. Valves of the operculum bipartite. Base cup-shaped and separate.

The *Acastæ* inhabit different sorts of sponge, in which they are found imbedded. We have observed several species in collections, but believe that two only have been described by authors, viz. Lepas spongites, *Poli*, tab. vi. fig. 3—6. and

Sp. 2. *Montagui*.—Lepas spongeosa, *Montagu Test. Brit. Suppl.* page 2. Plate LVII. natural size magnified, and with the operculum magnified.

B. *Base of the form of the substance to which it adheres.*

Gen. 12. Balanus *of authors*.

Shell sexpartite; two parts small and four large. Valves of the operculum bipartite.

Sp. 1. *Blainvillii*. Shell rugose, towards the opening striated deeply; operculum transversely striated; ridges produced into teeth on the anterior margin. Plate LVII.

This species is very common on the coast of Devonshire, adhering to rocks.

Gen. 13. Conia.

Shell quadripartite, parts equal. Valves of the operculum bipartite.

Sp. 1. *Porosa*.

Balanus porosus *of authors*.

Gen. 14. Clisia, *Savigny MSS.*

Shell quadripartite. Valves of the operculum undivided.

Sp. 1. *Striata*.

Balanus striatus. *Penn. Brit. Zool.* tab. 38. f. 7.

Inhabits the coast of Great Britain, being found attached to marine plants, crustacea, and testaceous mollusca. (v.)

Cirripedes || Clackmannanshire.

CLACKMANNANSHIRE, one of the counties of Scotland, situated between 56° 5′ and 56° 14′ north latitude, and between 3° 33′ and 3° 56′ west longitude from Greenwich, is bounded on the south and south-west, by the river Forth, which separates it from Stirlingshire, by Fifeshire on the south-east, and in every other quarter by Perthshire. It is the smallest county in Scotland, being little more than eight miles long, and, at a medium, six miles and a half broad; thus extending over 52 square miles, or 33,280 acres. But its value is much greater than in the ratio of its extent. About three-fourths of its surface are under cultivation, a greater proportion, with the exception of East Lothian, than that of any other county in Scotland; and it abounds in the useful minerals, which have long been wrought upon a very extensive scale.

Situation. Extent.

Between the Ochill-hills, which form the northern boundary of this district, and the rich alluvial tracts on the banks of the Forth, which winds along in a very irregular line on its opposite extremity, there is a considerable variety of surface. An elevated ridge rises on the west, and, running through the middle of the county, spreads itself gradually till it reaches the eastern boundary, skirting the alluvial or carse lands on the south, and the vale of Dovan on the north. And still farther to the north, the Ochill-hills, the highest of which, Bencloch, in the parish of Tillicoultry, rises nearly 2500 feet above the level of the sea, form a very picturesque landscape, having their generally verdant surface broken by bold projecting rocks, and deeply indented ravines, the beds of many a pellucid stream; with coppice and thriving plantations occasionally interspersed. These hills protect the lower grounds from the piercing winds that blow from the north and north-east, and give Clackmannanshire some advantage, in regard to climate, over the adjoining counties.

Surface.

The only streams worth notice, which traverse this county, are the Dovan and the Black Dovan, or, as they are often called, the North Devon and South Devon. The Dovan rises in the county of Perth, and, descending with impetuosity from the Ochills, where its course is to the east, makes a very acute turn towards the west, and, proceeding placidly in that direction through the pleasant vale already mentioned, falls into the Forth at the village of Cambus. Exclusive of its windings, the course of this river is more than 26 miles, though the distance in a direct line from its source to its *embouchure* does not exceed six miles. It has long been re-

Rivers.

Clackmannanshire.

markable for the deep and dark chasms which it has worn in the rocks, through which it flows in the earlier part of its course, and in which it is in some places hardly visible. The *Devil's Mill*, so called from the supposed resemblance of the sound of the water to that of machinery; the *Rumbling Bridge*, a very narrow and unguarded pass across a chasm 90 feet deep; and the *Cauldron Lynn*, where the water is perpetually agitated in the immense cauldron-like excavations which it has formed in the rock, have been frequently visited by the lovers of natural scenery. Though this river is liable to be suddenly swelled by rains, and frequently descends in torrents overflowing its banks, it is in general of no great depth, but it is said might be rendered navigable for small vessels at a moderate expence, to the effect of bringing 10,000 acres of coal within reach of water carriage.

The Black Dovan has its source in the county of Fife, flows westward in a direction nearly parallel to the Dovan, and falls into the Forth near Clackmannan. This river is extensively employed in driving mills and coal engines, its whole course being over coal strata. In a dry season, it is an inconsiderable stream, the greater part of its waters being then collected into reservoirs for the supply of machinery.

The Forth is navigable as far as it forms the boundary of this county. Ships of 500 tons burden come up as far as Alloa. Its windings or *links*, as they are called, are very remarkable. The distance from the quay of Alloa to that of Stirling, measured in the middle of the stream, is 17 miles, and to the bridge of Stirling it is $19\frac{1}{2}$, whereas the distance by land from the latter place to Alloa does not exceed seven miles. A little above Alloa there are three islets in the river, the largest containing more than 70 acres. A remarkable ledge of rock stretches across the Forth below the two smaller islets, which obstructs the passage of vessels of more than 60 tons burden, and where it is fordable at low water of spring tides. The breadth at this place being only about 500 yards, it was long since proposed to throw a bridge over it, the expence of which was estimated at L.70,000. Mr Rennie, the celebrated engineer, has made a survey with a view to a bridge at the Alloa ferry, which he declared to be practicable at an expence of L.150,000; a work which it has been very lately attempted to set a going by means of a loan from Government, but with little probability of success. The estuary of the Forth, for several miles above and below Clackmannan, exhibits a singular phenomenon in its tides, which rise there from 16 to 22 feet. During neap tides in good weather, and sometimes also during spring tides, if the weather be uncommonly fine, after the water has flowed for three hours, it retires in an hour and a half, nearly as far as the line from which it had begun to flow, returning immediately, and, in an hour and a half more, reaching the same height it had attained before. This flux and reflux takes place both in the flood and ebb tides, so that double the usual number of tides occur in this part of the river. In very boisterous weather, however, these *leaky tides*, as they are called by sailors, are not regular, the water then only rising without any perceptible current, as if two tides were acting against each other.

The soils of the arable land of Clackmannanshire are in general productive and well cultivated; though the greater part of the elevated range which is interposed between the carse lands on the Forth, and the vale of Dovan at the bottom of the Ochill hills on the north, consists of inferior soils, often incumbent on an impervious clay. All the crops commonly raised in Scotland grow luxuriantly on either side of this tract, which also contains within itself a considerable proportion of valuable soil. From the rental of the Abbacy of Cambuskenneth, founded in 1147, it appears, that wheat was cultivated on the *links* of the Forth, at a very early period, yet it is certain that, forty years ago, fields of this grain were only occasionally to be met with in the county. As a proof how early and well the carse lands near Alloa have been cultivated, it may be mentioned, that more than a century ago, some farms in that quarter paid as much grain and other kinds of produce, as rent, as the present money rent of similar soils would purchase at the average prices of the last twenty-five years. The farms would be thought small in other counties, few of the arable ones exceeding 200 Scotch (250 English) acres; and the far greater number being below 100 acres. The rent of the county was returned to the collector of the property-tax for the year ending April 1811, at L. 32,047, 12s., so that, after making allowance for what part of the surface is covered by water, or otherwise altogether unproductive, every acre must have paid at least 20s. upon an average of all soils and situations. At the same time, the rent of the houses was stated at L. 2,827, 5s. The old valuation, by which land-tax and county-rates are apportioned, is L. 26,482, 10s. 10d. Scots, or L. 2,206, 17s. 7d. Sterling, of which somewhat more than a third belongs to estates held under entail. The first effective thrashing machine in Scotland was constructed at Kilbagie, in the parish of Clackmannan, in 1787, by Mr George Meikle, the son of its celebrated inventor; and the last one, it is believed, at which old Meikle himself worked, is on the estate of Mr Erskine of Mar, near Alloa, and still in complete repair. One of the greatest disadvantages which the agriculture of this district labours under, is the want of limestone, of which, however, very large quantities are procured by the farmers from the quarries near Dunbar, and afterwards calcined in the county, where coal is always plentiful and cheap. Limestone that has already undergone this process is also imported to a considerable extent from the Earl of Elgin's works in Fife.

Crops.

Farms.

Rent.

Thrashing Mills.

Minerals.

This small county is rich in minerals. Silver, copper, lead, iron-ore *(hæmatites)*, cobalt, and arsenic, have all been discovered in the Ochill mountains, between Airthry and Dollar; but, after having been wrought for a time with little success, the labour has been discontinued. The operations, however, were not conducted upon an extensive scale; in no instance did the miners penetrate below the level of the plain from which the Ochills rise; and it is still believed that these hills abound in valuable metallic veins, ready

Clackmannanshire.

to reward more skilful and enterprising adventurers. Ironstone is wrought to a considerable extent for the Devon iron-works in the parish of Clackmannan. It is found either in strata, or in detached oblate balls, imbedded in the schist, and yields from 25 to 30 *per cent.* of iron.

Millstones.

The Abbey Craig, near Stirling, a great mass of greenstone rock, crystallized in the internal structure, and rudely columnar in its external appearance, deserves to be particularly noticed, in this general view of Clackmannanshire, for its having afforded a very useful substitute, in the manufacture of flour, for the French bur-stones, which it was so difficult to procure during the late war. This discovery was made by a miller of the name of James Brownhill, then employed at the Alloa mills. Several hundreds of these millstones are now working both in England and Scotland, and are found to be in some respects superior to the burs. The *Society for the Encouragement of Arts* in London presented this ingenious person with 100 guineas for his discovery, after they had received the most satisfactory proofs of its great importance.

Coal.

Coal has been wrought for 200 years in this county. The present annual output may be estimated at 130,000 tons, of which a great part is shipped for Leith, Dunbar, and Tay water, and the remainder consumed by manufactories near the collieries, and by private families. In the scale of working, the collieries stand thus: 1 Alloa. 2. Sauchy. 3. Clackmannan. 4. Dollar. 5. Kennet. 6. Tillicoultry; besides partial workings in every parish in the county, Logie excepted. It is all either cubical or slate coal (both are often found in the same bed), of an open burning quality; no smithy or caking coal having yet been discovered. The thinnest seam which has been wrought is 27 inches thick; and in a depth of 105 fathoms, there are nine seams of more than this thickness. The strata which compose the coal-field are varieties of sandstone, argillaceous schistus, fire-clay, and argillaceous ironstone. Limestone is found among the lowest veins of the coal strata. Organic remains of shell-fish and plants abound in them. Of the latter, many are of a kind now found only in the equatorial regions. Carbonic acid gas, termed choak-damp, is the most abundant of the noxious vapours found in the coal mines of this field. Hydrogen gas, or inflammable air, was never known here till lately, and it is still in small quantity. The great coal field of Scotland, which passes in a diagonal line from the mouths of the Forth and Tay to the Irish sea, is bounded by the Ochill hills. No coal has been found to the north of them, excepting at Brora, in the county of Sutherland.

Machinery.

Machinery for drawing water from the mines was constructed and much improved in this county, before the invention of the steam-engine. The Alloa colliery is drained by an overshot water wheel, 30 feet diameter, which lifts the water from the depth of 300 feet. The Sauchy collieries are drained by powerful steam engines; that employed by the Devon Company is capable of raising 1,000,000 gallons of water in twenty-four hours from the depth of 280 feet. At the Alloa colliery there is an improved cast-iron railway of about $2\frac{1}{2}$ miles in length, upon which a horse takes down eight waggons with as many tons of coals. The general price paid for working great coal is from 2s. to 3s. *per* ton; and the selling price on the hill 6s. 8d., which is said to yield but a very small return to the coal-master.

Collier's Court.

At the Alloa colliery, the workmen have for a great number of years had a court composed of five of their own number, appointed annually by the proprietor of the works. By this court all differences amongst themselves are settled. The highest fine exacted is half a guinea, and all the fines go into a general fund for the support of the poor.

Manufactures.

Under the head of manufactures, the distilleries of this county form by far the most prominent and considerable branch. In this small district there are no fewer than six large distilleries, of which Kilbagie and Kennetpans are the most extensive. These two paid to Government an excise duty greater than the land-tax of Scotland: the former alone, no less, at one time, than about half a million Sterling. Previous to 1788, the quantity of grain annually consumed at Kilbagie exceeded 60,000 bolls (45,000 quarters); and 7000 cattle and 2000 swine were fattened upon the grains and dreg. The saving in the stock of food for man, effected by the stoppage of the distilleries, is therefore much less considerable than has been imagined: an acre of barley used in distillation yielding nearly as much animal food as an acre of middling pasture. It is understood that cattle may be fattened in a complete manner, in the proportion of two, of 50 stone avoirdupois each, for every gallon of a still when working from grain; affording the means, at the same time, of enriching the soil for future crops, by the abundance and good quality of the manure they produce.

Iron-works.

The other manufactures of Clackmannanshire, though numerous, are not conducted upon so very extensive a scale. At the Devon iron-works, already noticed, about 60 tons of pig iron are prepared weekly, only a small part of which is used by the foundery at these works. In the parish of Dollar, on the banks of the Dovan, a bleachfield was established in 1787, of which the water and the machinery are excellent. The cloth bleached here consists chiefly of the fine table linen manufactured at Dunfermline. There is a very complete set of corn mills at Alloa, and mills for various purposes in several quarters of the county. To the west of the ferry at Alloa, a glass-work for making bottles has been erected; and, in the neighbourhood, a tile and brick work, and a tannery.

Commerce.

The Port of Alloa is well situated for commerce, and has a substantial well built quay, and, a little above the harbour, a dry dock, capable of receiving vessels of large burden; the depth of the water at spring tides being 16 feet, and the width of the gates $34\frac{1}{2}$. There is a custom-house here, which comprehends within its precincts the Creeks of Stirling, Kincardine, and Clackmannan pow, at which 120 vessels are registered, carrying 9000 tons, and navigated by 476 men. There are cleared outwards annually, on an average, from 900 to 1000 vessels, carrying 50,000 tons, and employing about

Shipping.

Clackmannanshire.

2500 seamen. The principal exports are coals, pig-iron, and British spirits, sometimes to the extent of nearly a million of gallons, the greater part of which is carried to the English market. The annual average of the import cargoes is from 400 to 500, consisting, for the most part, of grain for the distilleries, of which a great proportion is barley from the county of Norfolk; or of sugar from Leith, Glasgow, Greenock, London, and Liverpool, when the distilleries work from that article. Timber, iron, and other commodities, are occasionally imported from the Baltic.

Packets.

The establishment of packets betwixt Alloa and Leith is likely to prove of much benefit to this district from the low rates at which goods are transported.

Steam-boats.

A most convenient and expeditious conveyance for passengers, by means of steam-boats, has been recently introduced, with great success, between Newhaven and Alloa, and other places on the Forth.

Antiquities.

Among the antiquities of this county may be mentioned the ruins of Castle Campbell, originally called Castle Gloom, in a singularly wild and almost inaccessible situation, within a recess of the mountains, above the village of Dollar. The period of its erection and its early history are unknown. It became the property of the Argyle family in 1465, from whom it derived its present name, and was the ordinary residence of Archibald Earl of Argyle at the time of the Reformation. In this strong hold John Knox found a temporary retreat. In 1644 it was burned by Montrose, and since that time has been suffered to remain in ruin. The tower of Alloa, built prior to the year 1300, the residence of the Erskines, Earls of Mar, and now belonging to the representative of that noble family, is in good preservation. The walls are eleven feet in thickness, and the highest turret is eighty-nine feet from the ground. The tower of Clackmannan was long the seat of the chief of the Bruces, after the failure of the male line. There is a charter, dated 9th December 1359, quoted by Douglas, in which David II. grants to Sir Robert Bruce (whom he there styles his dearly beloved relation) the castle and manor of Clackmannan, with divers other lands within the county. Since the death of Henry Bruce of Clackmannan, in 1772, leaving no male representative, it has been made a question whether the Earl of Elgin or Bruce of Kennet be now the chief of that royal race.

Representation.

Clackmannanshire sends a member to Parliament alternately with the county of Kinross.

Parishes.

It contains only four parishes, viz. Clackmannan, Alloa, Dollar, and Tillicoultry, together with about a third part of the parish of Logie: the village of Cambuskenneth, in the parish of Stirling, also forms a part of this county. There is no royal burgh in it. Clackmannan, which gives its name to the county, the only town in it besides Alloa, deserves to be noticed rather for the beauty of its situation than for the elegance of its buildings, or the industry of its inhabitants.

Poor.

There is no assessment here for the poor, except in the parish of Logie, of which the proportion paid by this county a few years ago was from L. 13 to L. 14. The total number of poor in 1812 was 193, who received L. 673, or nearly L. 3, 10s. each, from interest of money, collections at the church doors, and other voluntary offerings.

Population.

The population of Clackmannanshire in 1800 and 1811 is exhibited in the following abstracts.

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
2100	2612	64	5064	5794	872	1037	8949	10,858

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
1995	2781	99	5715	6295	280	893	1608	12,010

Clare County. Situation.

CLARE, a county in the south-west of Ireland, is bounded on the north and north-east by the county of Galway, by the Shannon, which separates it, on the east, from Tipperary, and, on the south, from Limerick and Kerry, and on the west by the Atlantic Ocean. It is of a triangular form; its west and south sides meeting in a point at Cape Lean or Loop Head, on its south-west extremity, and the bounding line between it and Galway forming the base. It extends about 42 miles from north to south, and 66 from east to west; but, from the inequality of its breadth, contains little more than 1200 square miles, equal to 476,200 Irish, or 771,365 English acres, of which not quite a half is deemed productive land, and is chargeable with cess. Along all the coast from Galway Bay on the north, to the mouth of the Shannon on the south, a distance of 40 miles, there is no safe harbour for large vessels. On the banks of the Shannon and the Fergus, there are tracts of rich low ground, called *corcass*, of various breadths and irregular in form; and much of the higher lands, though rocky, yield excellent herbage for sheep; but a large proportion of the whole county consists of moors, mountains, and bogs, with more than a hundred lakes interspersed, and without the shelter of natural wood, and rarely of plantations, the extent of which is very limited. The climate, though moist, is not unfavourable to health and longevity; fevers, which sometimes prevail to a great extent here; being occasioned chiefly by the dampness of the houses, and inattention to domestic and personal cleanliness.

Extent. Surface. Climate.

Rivers.

The only rivers of any note in this county, or connected with it, are the Shannon and Fergus. The former, after almost dividing Ireland from north to south, enters the Atlantic Ocean between this county and Kerry, where it is about five miles broad. Vessels of 400 tons burden come up this river to the quay of Limerick, from whence the navigation is continued by a canal to Dublin. The Fergus, which has its source within the county, after passing through a number of lakes, and receiving the waters of several smaller streams, pursues its course through the town of Ennis, and, forming a beautiful estuary of picturesque islands, unites with the Shannon at about ten miles distance. It is navigable for vessels of 200 tons burden for about eight miles, and after heavy rains rises so considerably and rapidly, that it frequently overflows large tracts of meadows on its banks. *Turloghs*, called in other places *Loghans*, are numerous. These are accumulations of water, either forced under ground from a higher level, or surface-water from higher grounds, that have no outlet, and must remain until evaporated in summer. Although the water remains on them for several months, yet, on its subsiding, fine grass springs up and supports large herds of cattle and flocks of sheep during the dry season. Mineral waters are found in many places, to several of which, owing perhaps to their sanative virtues, superstition has assigned the name of holy wells.

Minerals.

Clare County is said not to be deficient in mineral productions, but these have not hitherto been turned to much account. Coal has been found, but the working of it is not prosecuted, and ironstone, of which there are strong indications, has never been sought for. Limestone abounds, and detached rocks of it are sometimes surrounded by bogs, where it may be calcined at a small expence. There are quarries of slate nearly equal to the Welsh, worked to some extent at Killaloe and Broadford. Very fine black marble has been found near Ennis; lead ore in various places; also manganese, copper, beautiful fluor spar, and antimony.

Agriculture.

The agriculture of this county would seem to have made little progress of late, some of the most recent writers on the statistics of Ireland still referring to Mr Arthur Young's *Tour*, written about 40 years ago, as if that work contained a faithful picture of the present state of the county. Clare, however, is not an exception to the advances that have been so generally made towards a more perfect system during that long period; though, in this important art, in which the far greater number of the people are employed, it is certainly far behind several counties on both sides of the Channel. All the different species of grain are cultivated here with considerable success. Rape and flax, the former chiefly for its seed, and the latter for home manufacture, are sown to a moderate extent. Potatoes occupy a part of every farm, and their culture is conducted with more care and judgment than that of any other crop, though at a greater expence of time and labour than would be thought necessary in most other places. In regard to the kinds of crops cultivated, the greatest defect is in what are called green crops, corn being, with potatoes, the chief and almost the only objects of attention to the arable farmer; and turnips and cultivated herbage being either grown on a very small scale, or, as is the case throughout the greater part of the county, altogether disregarded or unknown. The corn crops thus necessarily follow each other until the soil is exhausted; and where extra manure, such as sea-weed and sea-sand, both of which are used as manure with good effect, cannot be procured, it must be left in an unproductive state for several years afterwards. Potatoes are in most cases planted upon land that has been prepared by burning, and the same crop is sometimes taken for two years more without manure; in the fourth year, wheat follows, and then repeated crops of oats as long as they will replace the cost of seed and labour. The implements in common use are generally rudely constructed, and imperfect as well as expensive in their operation. In many parts, even where the soil is light and dry, the plough is drawn by four horses abreast, with traces of rope and collars of straw. But from the roughness of the surface, the poverty of the tenantry, and the minute division of farm lands, the spade is much more extensively employed than the plough, over all the arable land of this county.

Manures.

Pastures.

The pastures of the corcasses or low grounds on the rivers Shannon and Fergus, are equal to the fattening of the largest oxen. This rich tract extends from Paradise to Limerick, about 20 miles, and is computed to contain about 20,000 acres of a deep dark-coloured soil over a bluish or black clay, or moory substratum, producing, owing to the indolence of its occupiers, along with the most valuable herbage, a great quantity of rushes and other useless weeds. The rent of this land for grazing was seve-

Rent.

Clare County.

ral years ago as high as L. 5 *per* acre, equal to about L. 3, 2s. *per* English acre, and for meadow, in many instances, much more. These meadows are said to produce at the rate of more than four tons of hay the English acre. The cattle of this county are almost all long horned, good milkers, and very hardy. The sheep have been greatly improved in shape by crosses with Leicester rams, but there is a general complaint that the quality of the native wool has been deteriorated. A vast number of mules are bred here; asses are very generally employed by the poorer classes; but little attention is paid to the breed of horses, which has degenerated.

Live Stock.

Farms.

The size of farms varies greatly. Those under tillage are from one or two acres to fifty, but of the latter size there are few. Grazing farms extend from 100 to 800 acres, several of which, and sometimes in distant situations, are held by one individual. Frequently several persons join in the occupation of an arable farm, and have about ten acres each. The general term of leases, from proprietors, is for three lives or 31 years; sometimes, but not often, three lives and 31 years; 21 years or one life, and 21 years and a life. The tenure of under tenants is variable, and often arbitrary.

Leases

Orchards.

Clare was formerly noted for its orchards, and for cyder of a very fine quality made from the celebrated cackagee apple, which is still found near the small town called Six Mile Bridge. "An acre of trees," says Mr Young, "yields from four to ten hogsheads *per annum*, average six, and what is very uncommon in the cyder counties of England, yield a crop every year." It does not appear, from the latest accounts, that any considerable quantity of this cyder is now produced here, though what there is seems to maintain its former character, and is held in great estimation.

Manufactures.

Manufactures are yet in their infancy. All the linen made in the county is used for home consumption, the greater part of it being coarse and low priced. Some judgment may be formed of the extent of this branch, when it is known that there are but three small bleachfields in the county. Coarse woollens called frize, and worsted stockings, coatings at one establishment, broad cloth at another, and blankets at a third, with some serges, comprise all the products of the woollen manufacture to be found here, none of them upon an extensive scale, and affording very little for exportation. A considerable number of coarse hats are made near Skar; they are dyed with alder bark and twigs, and logwood, but principally the first. A great deal of kelp is made on the extensive shores of this county, but in so careless a manner that the value is considerably less than that of the kelp of Scotland, and brings only about two-thirds of its price *per* ton.

Fishery.

The fishery on this coast has not been prosecuted to any extent, though it is said that no part of Ireland is so well situated for carrying on a lucrative fishery. In the herring season there may be about 200 boats employed, but there is a want of proper regulations, and of authority to enforce such as there are. These boats are, in general, such as have been used from the remotest period of history, wicker-work, covered with hides. It is not uncommon for a man to exclude the access of the water through a rent in the hide with his foot, when such an accident happens at sea; he frequently applies his wig and other parts of his dress to the same purpose; and in this dangerous situation remains, with the utmost indifference, exposed to the violent surf that generally beats on this shore. Oysters, and crabs and lobsters, are caught in considerable quantity. The salmon-fishery of the Shannon is very valuable; a few of these fish are found in all the rivers that communicate with the sea. Eels, which abound in every rivulet, form another material article of consumpt, but the mischief occasioned by their *weirs* is probably greater than their value. Other kinds of fish are caught at particular seasons, but only in small quantities.

Clare County.

Population.

The population of Clare county is stated, conjecturally, at about 120,000; the number of houses being 18,050. Ennis, the county-town, and the only town of any size, may contain 9,000 inhabitants. The houses of the great body of the people are built of stone, without cement,—in the mountains and bogs, often of sods; and heath, fern, and sometimes potatoe haulm, are used instead of straw for thatch. On the damp and dirty floor, their beds of straw or hay are often shared with their pig and dog. So fond are they of the smoke, which they say keeps them warm, that, in cottages erected by proprietors with chimneys, they have been known to prevent its escape by placing a flat stone or turf on the top of the funnel. Yet out of these huts issue the sinewy arms and the daring spirits that contribute so much to the glory of our fleets and armies. Peat or turf, which abounds in every part of the country, is the only fuel; a labourer will cut as much of it in two days, as will serve his family for a year, and his wife and children save it. Potatoes, with or without milk, fish occasionally, and a few vegetables, compose their diet. The quantity of potatoes consumed by a family of six in a week, appears very great, being usually about 22 stones, or at the rate of 8½ lb. daily, for each; but the pig and the other domestic animals also partake of the meal, and strangers never meet with a refusal. The men are clothed in frize, and the women in flannel dyed a bad red, both articles the manufacture of the family; though when the latter go to chapel or market, they frequently dress in dimity and other cotton fabrics, which they procure in barter for the surplus of their domestic manufactures. The men frequently in summer, and the women almost always, go without shoes and stockings, and the latter are so tenacious of this custom, that it is with difficulty they can be persuaded to wear them when taken into gentlemen's houses. The wages of common labour are from 8d. to 10d. a-day. Fairs and markets are almost the only places where drunkenness prevails, but it commonly ends in a few broken heads, and sometimes a little swearing before a magistrate. Matters, however, are generally accommodated by the friends of the parties. Schools abound in this county, and in summer they are numerously attended, yet with a few exceptions, they are far from being under good management.

Houses.

Food.

Clothes.

Wages.

Schools.

Name.

Clare county was anciently called Thomond or Tuadmuin, that is, North-Munster. The origin of

Clare County || Climate.

its present name is disputed. In the year 1565, this district was made a county, and added to the province of Connaught, but was restored to Munster in 1602. It forms part of the united diocese of Killaloe and Kilfenora, is divided into nine baronies and seventy-nine parishes, having only, according to Dutton's survey, eighteen resident clergymen, and contains, besides Ennis already mentioned, the towns or rather villages of Killaloe, Kilrush, Innistymon, Six-Mile-Bridge, Corrofin, Kilfenora, Skarriff, and Miltown. The people are represented in the Parliament of the united kingdom by two members for the county, and one for the borough of Ennis. The proportion between the Protestants and Catholics has not been ascertained; but it is well understood that the latter are by far the most numerous. Except in the more remote situations of the county, the English language is pretty generally understood, though the Irish is spoken almost exclusively by the country people. It is not, however, used in the schools, nor by the children of the higher classes, and the English tongue must therefore soon become universal.

Divisions. Representation. Religion. Language. Antiquities.

Remains of ancient buildings, both religious and military, abound in this county. No less than 118 castles are enumerated, besides many *raths* or circular entrenchments of earth or stone, called Danish forts, and *cromlechs* supposed to be sepulchral monuments, one of which, at Balgannor, has a single stone about 40 feet long, and 10 feet broad. Scattery, a beautiful island in the mouth of the Shannon, is rich in these works of an early age. There is a tower on it 120 feet high, an useful land-mark to mariners, the ruins of a castle and several churches, and a monastery said to have been founded by St Patrick in the fifth century. This island is still remarkable for the resort of pilgrims on certain festivals. At a place called *Taumple, na Spanigg*, "the burial-place of the Spaniards," a part of the Spanish Armada was wrecked. There was an oak table on board one of the ships, of curious workmanship, which is yet in high preservation in the hall of Dromoland house, the seat of Sir Edward O'Brien.—See Young's *Tour in Ireland*, Vol. I.—Beaufort's *Memoir*, 1792.—Dutton's *Statistical Survey of Clare*, 1808.—Newenham's *View of Ireland*, 1809.—Wakefield's *Statistical and Political Account of Ireland*, 1812.—And, Mason's *Statistical Survey*, of which two volumes only are yet published. (A.)

CLIMATE.

The theory of climate, which is commonly treated in a very loose manner, would require much elaborate discussion, and a skilful application of the most refined principles in physical science. But, to form a solid basis for the superstructure, there are still wanted accurate and numerous meteorological facts, which can only be obtained from the diffusion of nice instruments, joined to the zeal of careful observers. We had, besides, expected before this time to have been able to embody the results of some new and delicate researches into the constitution and properties of our atmosphere. Those experiments, however, are not quite completed and brought to their ultimate degree of precision. We must, therefore, content ourselves for the present with tracing the great outlines, reserving the full exposition of the subject to the article METEOROLOGY.

Ancient Use of the word Climate.

The word *Climate*, or κλιμα, being derived from the verb κλινεῖν, *to incline*, was applied by the ancients, to signify that obliquity of the sphere with respect to the horizon from which results the inequality of day and night. The great astronomer and geographer Ptolemy, distinguished the surface of our globe from the Equator to the Arctic Circle, into climates or parallel zones, corresponding to the successive increase of a quarter of an hour in the length of midsummer-day. Within the tropics, these zones are nearly of equal breadth; but, in the higher latitudes, they contract so much, that it was deemed enough to reckon them by their doubles, answering consequently to intervals of half-an-hour in the extension of the longest day. To compute them is an easy problem in spherical trigonometry. As the sine of the excess of the semidiurnal arc above a quadrant is to the radius, so is the tangent of the obliquity of the ecliptic, or of 23° 28′, to the cotangent of the latitude. The semidiurnal arcs are assumed to be 91° 52½′, 93° 45′, 95° 37½′, 97° 30′, &c.; and the following table, extracted from Ptolemy's great work, will give some general idea of the distribution of seasons over the surface of our globe:

Climate, or Parallel.	Latitude.	Length of Midsummer day.	Breadth of Zone.
I.	0 0	12h. 00′	4° 15′
II.	4° 15′	12 15	4 10
III.	8 25	12 30	4 5
IV.	12 30	12 45	3 57
V.	16 27	13 00	3 47
VI.	20 15	13 15	3 38
VII.	23 51	13 30	3 21
VIII.	27 12	13 45	3 10
IX.	30 22	14 00	2 56
X.	33 18	14 15	2 42
XI.	36 00	14 30	2 35
XII.	38 35	14 45	2 21
XIII.	40 56	15 00	2 9
XIV.	43 4	15 15	1 57
XV.	45 1	15 30	1 50
XVI.	46 51	15 45	1 41
XVII.	48 32	16 00	1 32
XVIII.	50 4	16 15	1 36
XIX.	51 40	16 30	1 10
XX.	52 50	16 45	1 40
XXI.	54 30	17 00	1 30
XXII.	55 00	17 15	1 00
XXIII.	56 00	17 30	1 00
XXIV.	57 00	17 45	30
XXV.	58 00	18 00	
XXVI.	59 30	18 30	

Climate.

These numbers are calculated on the supposition that the obliquity of the ecliptie was 23° 51′ 20″, to which, according to the theory of Laplace, it must have actually approached in the time of Ptolemy. They seem to be affected by some small errors, especially in the parallels beyond the seventeenth, as the irregular breadth of the zone abundantly shows; but they are, on the whole, more accurate than those given by Varenius.

Ptolemy describes the general appearances which the heavens will present on each parallel, and assigns the corresponding lengths of the shadow of the gnomon at both solstices. He justly maintains, in opposition to the more ancient opinion, that the equatorial region is habitable, since the action of the sun, not continuing long vertical, is there mitigated; but he will not venture to describe the inhabitants, because, no person, he says, having yet penetrated so far south, the reports circulated respecting them appeared to be merely conjectural. He therefore passes over the first parallel to the second.

This *second* parallel, then, according to Ptolemy, runs through the isle of Taprobana, supposed to be Ceylon, in the latitude of 4° 15′. The *third* parallel, in the latitude of 8° 25′, traverses the gulf of *Aualitus*. The *fourth* parallel crosses the *Adulitic* gulf, in latitude 12° 45′. The *fifth* parallel passes through the isle of *Meröe*, in Upper Egypt, at latitude 16° 27′. The *sixth* parallel runs through the territory of the *Napati*, in latitude 20° 15′. All these climates or parallels, lying below the tropic, the inhabitants are therefore *Amphiscians*, or see the sun pass twice over their heads in the course of the year. The *seventh* parallel, at the latitude of 23° 51′, and consequently bordering the tropic, runs through Syenè in Upper Egypt. The *eighth* parallel, in latitude 27° 12′, traverses Ptolemais in the Thebaid. The *ninth* zone, corresponding to a day of 14 hours of length, passes through Lower Egypt, at the latitude of 36° 12′. The *tenth* parallel, in latitude 33° 18′, runs through the middle of Phœnicia. The *eleventh* parallel, at the 36th degree of latitude, passes through the isle of Rhodes. The *twelfth* parallel, in latitude 38° 35′, crosses Smyrna. The *thirteenth* parallel traverses the Hellespont, in latitude 40° 56′. The *fourteenth* parallel, in latitude 43° 4′, runs through Marseilles. The *fifteenth* parallel passes through the middle of the Pontic Sea, in latitude 45° 1′. The *sixteenth* parallel runs through the sources of the Ister or Danube, in latitude 46° 51′. The *seventeenth* parallel, corresponding to a day of 16 hours in length, traverses the mouths of the Borysthenes, in latitude 48° 32′. The *eighteenth* parallel, at the latitude of 50° 4′, crosses the Palus Mæotis. The *nineteenth* parallel passes through the most southern part of Britain, in latitude 51° 40′. The *twentieth* parallel crosses the mouths of the Rhine, in latitude 52° 50′. The *twenty first* parallel passes through the mouths of the Tanaïs, in latitude 54° 30′. The *twenty-second* parallel, at the 55th degree of latitude, traverses the country of the *Brigantes* in Great Britain, that is, the southern and larger portion of this island, reckoning from the Firth of Forth. The *twenty-third* parallel, in the 56th degree of latitude, passes through the middle of Great Britain. The *twenty-fourth* parallel, at the latitude of 57°, runs through *Caturactonium* in Great Britain. The *twenty-fifth* parallel, corresponding to a day of 18 hours long, runs through the southern parts of Little Britain, in latitude 58°. The *twenty-sixth* parallel, corresponding to a day of 18½ hours in length, traverses the middle of Little Britain, in latitude 59° 30′. It should be observed that the latitudes of the places in our own island are most inaccurately given by Ptolemy, and generally advanced about two or three degrees farther north than their true position. By Little Britain, he meant undoubtedly that part of Scotland which lies on the north side of the Firths of Forth and Clyde, and forms almost a peninsula.

The high zones become so narrow, that Ptolemy separates the *twenty-sixth* to an interval of half instead of a quarter of an hour in the length of the day; but he thinks it superfluous to extend this subdivision farther into such remote and inhospitable countries. Resuming the calculation, however, he places the parallel where midsummer day is prolonged to 19 hours in the latitude of 61°, or the north of Little Britain. The parallel of 19½ hours would pass through the Ebudes, or Western Isles, in latitude 62°. The parallel of 20 hours runs through the island of Thule, in the latitude of 63°. The parallel of 21 hours would traverse the unknown Scythian nations, in latitude 64½°. The parallels of 22 and 23 hours would run through the latitudes of 65½° and 66°. He places in latitude 66° 8′ 40″ the Arctic Circle itself, where the sun does not set during the whole of midsummer day. Within this circle, the inhabitants are *Periscians*, or have the sun lingering above the horizon during part of the summer, and the shadow of the gnomon successively projected in every direction. In the latitude of 67°, the sun continues almost a whole month above the horizon; in the latitude of 69½°, he shines two months; and, in the latitudes of 73⅓°, 78⅓°, and 84°, that luminary displays his presence for three, four, and five months. At the pole itself, the sun appears, during the space of six months, describing circles parallel to the horizon.

Modern Application of this word.

CLIMATE, in its modern acceptation, signifies that peculiar condition of the atmosphere in regard to heat and moisture which prevails in any given place. The diversified character which it displays, has been generally referred to the combined operation of several different causes, which are all reducible, however, to these two—*distance from the equator*,—and *height above the level of the sea*. Latitude and local elevation form, indeed, the great bases of the law of Climate, and any other modifications have only a partial and very limited influence.

Temperature below the Surface of the Earth.

If we dig into the ground, we find the temperature to become gradually more steady, till we reach a depth of perhaps forty or fifty feet, below which it continues unchanged. When this perforation is made during winter, the ground gets sensibly warmer till the limit is attained; but, in summer, on the contrary, it grows always colder, till it has gained the same limit. At a certain depth, therefore, under the surface, the temperature of the ground remains quite permanent. Nor is there any indication whatever of the supposed existence of a central fire,

Climate. since the alleged increase of heat near the bottom of the profoundest excavations is merely accidental, being occasioned by the multitude of burning tapers consumed in conducting the operations of mining. Accordingly, while the air of those confined chambers feels often oppressively warm, the water which flows along the floors seems comparatively cold, or rather preserves the medium heat.

It would be a hasty conclusion, however, to regard this limit of temperature as the natural and absolute heat of our globe. If we dig on the summit of a mountain or any very elevated spot, we shall discover the ground to be considerably colder than in the plain below; or, if we make a similar perforation on the same level, but in a more southern latitude, we shall find greater warmth than before. The heat thus obtained at some moderate depth is hence only the mean result of all the various impressions which the surface of the earth receives from the sun and the atmosphere.

The method employed hitherto for ascertaining the temperature at different depths under ground, consists in digging a hole, and burying a sluggish thermometer for several hours, or the space of a whole night. The celebrated naturalist and accurate observer, Saussure, in the month of October 1785, made an interesting set of observations on the banks of the Arve, near Geneva. By digging downwards on successive days, he reached at last the depth of 31 feet. While the surface of the ground had retained a heat of 60°.3 by Fahrenheit's scale, the temperature of the earth at the depth of 4 feet was 60°.8, at 16 feet 56°, at 21 feet 53°.6, and at 28 feet 51°.8. A thermometer buried 31 feet deep was found, when taken up in summer, to stand at 49°.5, and, when raised in winter, to indicate 52°.2. Notwithstanding this great depth, therefore, it had still felt the vicissitude of the seasons, having varied 2°.7 in the course of the year. The extreme impressions must have taken six months to penetrate to the bulb, since the temperature was lowest in summer and highest in winter.

But this plan of observing is clumsy and imperfect, there not being sufficient time to allow the mass of earth to regain its proper degree of heat, and too much for the instrument to retain its impression unaltered before it can be raised up and observed. In order to throw distinct light on a subject so curious and important, Robert Ferguson, Esq. of Raith, a gentleman whose elegant mind is imbued with the love of science, caused, lately, a series of large mercurial thermometers, with stems of unusual length, to be planted in his spacious garden at Abbotshall, about 50 feet above the level of the sea, and near a mile from the shore of Kirkaldy, in latitude 56° 10′. The main part of each stem having a very narrow bore, had a piece of wider tube joined above it; and to support the internal pressure of the column of mercury, the bulbs were formed of thick cylinders. The instruments, inclosed for protection in wooden cases, were then sunk beside each other to the depths of one, two, four, and eight feet, in a soft gravelly soil, which turns, at four feet below the surface, into quicksand, or a bed of sand and water. These thermometers were carefully observed from time to time by Mr Charles Norval, the very intelligent gardener at Raith; and we have now before us a register of their variations for nearly three years. It thence appears, that, in this climate and on naked soil, the frost seldom or never penetrates one foot into the ground. The thermometer at that depth fell to 33° of Fahrenheit on the 30th December 1815, and remained at the same point till the 12th February 1816; but, in the ensuing year, it descended no lower than 34°, at which it continued stationary from the 23d December 1816 to 1st January 1817. At the same depth, of one foot, it reached the maximum 58° on the 13th July 1815, but, in the following year, it rose only to 54°, on the 21st July; and, in the year 1817, it mounted to 56°, about the 5th July. This thermometer, in the space of three years, travelled, therefore, over an interval of 25°, the medium being $45\frac{1}{2}$, and attained its highest and lowest points about three weeks after the solstice of summer and of winter.

Climate. Depth to which Frost penetrates.

The thermometer planted at the depth of two feet, sunk to 36° on the 4th February 1816; but it stood at 38° about the beginning of January 1817. It rose to 56° on the 1st of August 1815; but, in the next year, it reached only 53°, on 24th July; and, in 1817, it again reached 56°, on 10th July. At the depth of two feet, the extreme variation was, therefore, 20°; and the maxima and minima took place about four or five weeks after either solstice.

The thermometer of four feet depth had sunk to 39° about the 11th February 1816; and was stationary at 40°, near the 3d February 1817. It rose to 54°, on the 2d August 1815; and stood at 52° during the greater part of August and September in the years 1816 and 1817. It ranged, therefore, only 15°, the mean being $46\frac{1}{2}$°, and the extreme points occurring near two months after either solstice.

The thermometer, whose bulb was planted eight feet deep, descended to 42° on the 16th February 1816, but stood at $42\frac{1}{2}$° on the 11th February 1817. It rose to $51\frac{1}{2}$° on the 12th September 1815, fell to 50° on the 14th September 1816, and mounted again to 51° on the 20th September 1817. This thermometer had, therefore, a range of only $9\frac{1}{2}$°, the medium temperature being $46\frac{3}{4}$°, and the extremes of heat and cold occurring nearly three months after the solstice of summer and of winter.

These observations are quite satisfactory, and exhibit very clearly the slow progress by which the impressions of heat or cold penetrate into the ground. It will not be far from the truth to estimate the rate of this penetration at an inch every day. The thermometers hence attained their maximum at different periods, though in a tolerably regular succession. The mean temperature of the ground, however, seemed rather to increase with the depth; but this anomaly has evidently proceeded from the coldness of the two last summers, and particularly that of 1816, which occasioned such late harvests and scanty crops. Thus, the thermometer of one foot indicated the medium heat of only 43°.8 during the whole of the year 1816. But it will be satisfactory to exhibit the leading facts in a tabular form. The following are the mean results for each month, only those for December 1817 are supplied from the corresponding month in 1815:

	1816.				1817.			
	1 foot.	2 feet.	4 feet.	8 feet.	1 foot.	2 feet.	4 feet.	8 feet.
January	33°.0	36°.3	40°.7	43°.0	35°.6	38°.7	40°.5	45°.1
Feb. .	33 .7	36 0	39 .0	42 .0	37 .0	40 .0	41 .6	42 .7
March	35 .0	36 .7	39 .6	42 .3	39 .4	40 .2	41 .7	42 .5
April .	39 .7	38 .4	41 .4	43 .8	45 .0	42 .4	42 .6	42 .6
May .	44 .0	43 .3	43 .4	44 .0	46 .8	44 .7	44 .6	44 .2
June .	51 .6	50 .0	47 .1	45 .8	51 .1	49 .4	47 .6	47 .8
July .	54 .0	52 .5	50 .4	47 .7	55 .2	55 .0	51 .4	49 .6
August	50 .0	52 .5	50 .6	49 .4	53 .4	53 .9	52 .0	50 .0
Septem.	51 .6	51 .3	51 .8	50 .0	53 .0	52 .7	52 .0	50 .7
October	47 .0	49 .3	49 .7	49 .6	45 .7	49 .4	49 .4	49 .8
Novem.	40 .8	43 .8	46 .3	45 .6	41 .0	44 .7	47 .0	47 .6
Decem.	35 .7	40 .0	43 .0	46 .0	37 .9	40 .8	44 .9	46 .4
Mean of whole Year.	43 .8	44 .1	45 .1	46 .0	44 .9	45 .9	46 .2	46 .6

If the thermometers had been sunk considerably deeper, they would, no doubt, have indicated a mean temperature of 47°.7. Such is the permanent temperature of a copious spring which flows at a short distance, and about the same elevation, from the side of a basaltic or greenstone rock. Profuse fountains and deep wells, which are fed by percolation through the crevices of the strata, furnish the surest and easiest mensuration of the temperature of the earth's crust. The body of water which bursts from the caverns of Vaucluse, and forms almost immediately a respectable and translucid river, has been observed not to vary in its temperature, by the tenth part of a degree, through all the seasons of the year. It is, therefore, an object highly important for scientific travellers, to notice the precise heat of springs in favourable situations, as they issue from their rocky beds. Such choice observations would accurately fix the medium temperature of any climate. It is only requisite to exclude the superficial and the thermal springs, which are not difficult to distinguish.

Rule for Calculating the Mean Temperature of any Place.

From a comparison of meteorological observations made at distant points on the surface of our globe, the celebrated Astronomer Professor Mayer of Göttingen, was enabled to discover an empirical law which connects most harmoniously the various results. Round the pole, the mean temperature may be assumed at the precise limit of freezing, since the fields of ice accumulated in that forlorn region seem at this present period neither to increase nor diminish. But under the equator the medium heat on the level of the sea is found to be $84\frac{1}{5}$° of Fahrenheit, or 29 centesimal degrees, the division of the thermometric scale which is the best suited to philosophical purposes. At the middle point, or the latitude of 45°, the temperature is likewise the exact mean, or $14\frac{1}{2}$° centigrade. From that centre, the heat diminishes rapidly northwards, and increases with equal rapidity towards the south. Hence the mean temperature of any place, at the level of the sea, is calculated in centesimal degrees, by multiplying the square of the cosine of the latitude into the constant number 29; or it is found by multiplying the supplemental versed sine of double the latitude into $14\frac{1}{2}$°. The variation of temperature for each degree of latitude is hence denoted centesimally, with very great precision, by half the sine of double the latitude; being, in fact, this quantity diminished in the ratio of 58, the double of 29, to 57.3, the length of an arch equal to the radius. From these data, the following table is computed; in which are likewise annexed the corresponding degrees of Fahrenheit's, with the successive differences.

Lat.	Centesimal.	Diff.	Fahrenheit.	Diff.
0	29°.00	.00	84°.2	.00
1	28 .99	.01	84 .2	.02
2	28 .96	.03	84 .1	.05
3	28 .92	.04	84 .0	.07
4	28 .86	.06	83 .9	.11
5	28 .78	.08	83 .8	.13
6	28 .68	.10	83 .6	.18
7	28 .57	.11	83 .4	.20
8	28 .44	.13	83 .2	.23
9	28 .29	.15	82 .9	.27
10	28 .13	.16	82 .6	.30
11	27 .95	.18	82 .3	.32
12	27 .75	.20	82 .0	.36
13	27 .53	.22	81 .6	.40
14	27 .30	.23	81 .1	.42
15	27 .06	.24	80 .7	.44
16	26 .80	.26	80 .2	.47
17	26 .52	.28	79 .7	.50
18	26 .23	.29	79 .2	.52
19	25 .93	.30	78 .7	.54
20	25 .61	.32	78 .1	.57
21	25 .28	.33	77 .5	.60
22	24 .93	.35	76 .9	.63
23	24 .57	.36	76 .2	.65
24	24 .20	.37	75 .6	.67
25	23 .82	.38	74 .9	.68
26	23 .43	.39	74 .2	.70
27	23 .02	.41	73 .5	.72
28	22 .61	.42	72 .7	.74
29	22 .18	.43	71 .9	.76
30	21 .75	.43	71 .1	.77
31	21 .31	.44	70 .3	.79
32	20 .86	.45	69 .5	.81
33	20 .40	.46	68 .7	.83
34	19 .93	.47	67 .9	.84
35	19 .46	.47	67 .0	.85
36	18 .98	.48	66 .2	.86
37	18 .50	.48	65 .3	.87
38	18 .01	.49	64 .4	.88
39	17 .50	.49	63 .5	.88
40	17 .01	.49	62 .6	.89
41	16 .52	.49	61 .7	.90
42	16 .02	.50	60 .8	.90
43	15 .52	.50	59 .9	.91
44	15 .01	.51	59 .0	.91
45	14 .50	.51	58 .1	.92

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Lat.	Centesimal.	Diff.	Fahrenheit.	Diff.
46	13°.99	.51	57°.2	.92
47	13 .49	.50	56 .3	.91
48	12 .98	.51	55 .4	.91
49	12 .48	.50	54 .5	.90
50	11 .98	.50	53 .6	.90
51	11 .49	.49	52 ,7	.89
52	10 .99	.50	51 .8	.90
53	10 .50	.49	50 .9	.88
54	10 .02	.48	50 .0	.87
55	9 .54	.48	49 .2	.86
56	9 .07	.47	48 .3	.85
57	8 .60	.47	47 .5	.84
58	8 .14	.46	46 .6	.83
59	7 .69	.45	45 .8	.81
60	7 .25	.44	45 .0	.79
61	6 .82	.43	44 .3	.78
62	6 .39	.43	43 .5	.77
63	5 .98	.41	42 .8	.76
64	5 .57	.41	42 .0	.74
65	5 .18	.39	41 .3	.71
66	4 .80	.38	40 .6	.68
67	4 .43	.37	40 .0	.67
68	4 .07	.36	39 .3	.65
69	3 .72	.35	38 .7	.63
70	3 .39	.33	38 .1	.60
71	3 .07	.32	37 .5	.57
72	2 .77	.30	37 .0	.54
73	2 .48	.29	36 .5	.52
74	2 .20	.28	36 .0	.50
75	1 .94	.26	35 .5	.47
76	1 .70	.24	35 .1	.43
77	1 .47	.23	34 .6	.41
78	1 .25	.22	34 .2	.40
79	1 .05	.20	33 .9	.36
80	.86	.19	33 .6	.34
81	.71	.17	33 .3	.31
82	.56	.15	33 .0	.27
83	.43	.13	32 .8	.23
84	.32	.11	32 .6	.20
85	.22	.10	32 .4	.18
86	.14	.08	32 .3	.15
87	.08	.06	32 .2	.11
88	.04	.04	32 .1	.07
89	.01	.03	32 .0	.05
90	.00	.00	32 .0	.01

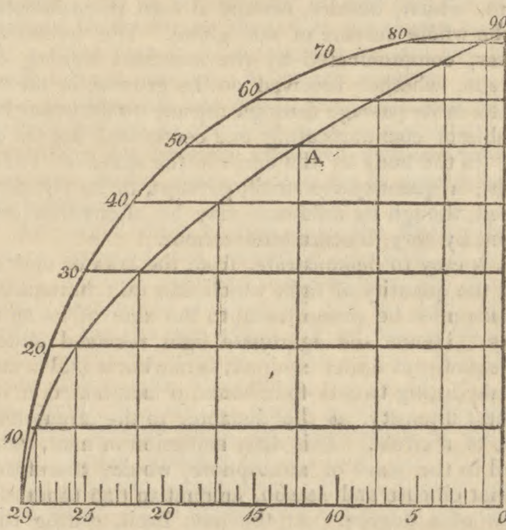
Little Variation of the Mean Temperature at the Poles and Equator.

It hence appears, that, near the extremities of the quadrant, or towards the pole and the equator, there is scarcely any sensible variation of the mean temperature, and that the whole change within the arctic circle, or between the tropics, amounts only to 8 degrees on Fahrenheit's scale. Very little increase of heat is, therefore, observed in advancing through the torrid zone to the equator; and the intensity of the cold would not be sensibly augmented in penetrating from the arctic circle to the pole. The existence of an open sea towards the extreme north is hence not improbable.

Great Changes of Temperature in the Temperate Zones.

On the other hand, the character of the climate changes rapidly in the temperate zone. Hence likewise the variety of vegetable productions with which those happier regions abound. Such a country as France, for example, stretching from about the 40th to the 50th degree of latitude, and through a difference of five centesimal degrees of mean temperature, yields not only plentiful crops of wheat, barley, and oats, but raises olives, fig-trees, and vines.

The gradation of temperature in different latitudes may be clearly shown by a geometrical diagram. Let the figure below represent a quadrant, 90 the pole, and



50 the latitude of any place; on the radius as an axis and a parameter, describe a parabola, which will consequently pass through the pole; draw the perpendicular 50 B, and the portion of it AB, intercepted within the parabola, will express the mean temperature of the given place at the level of the sea, which in the present case should amount to 12 centesimal degrees.

Since each elementary zone of the sphere is equal to the corresponding belt of a circumscribed cylinder, the whole heat accumulated on its surface must be proportional to the area of the annexed parabola, and, consequently, the mean temperature is two-thirds of what obtains at the equator, and, therefore, $19\frac{1}{2}^{0}$ or $66^{0}\ 8'$ on Fahrenheit's scale. Such must be the temperature of the great mass of the earth, if it has derived all its heat from external impressions. But, at the very small depths to which we can ever penetrate, the influence of the immediate vicinity only is felt; nor, in the profoundest mines, has any tendency been yet perceived towards increase of temperature in the higher latitudes, or of decrease in the lower.

Calculation of the Effects of the Sun's Rays.

These superficial impressions are all produced either directly, or through the intervention of the atmosphere, by the action of the solar rays. It may be calculated from experiment, that the entire and unimpaired light of a vertical sun will communicate one centesimal degree of heat every hour to a sheet of water of a foot in thickness. Consequently, since the surface of a sphere is four times that of its generating circle, such a sheet of water, spread over the

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whole of the globe, would receive six degrees of heat every day. But the very inferior capacity of the atmosphere for heat, being estimated as equal to that of a body of water about 12 feet in depth, if the aërial mass finally received and retained all the calorific impressions, it would every day have its temperature raised half a degree, and, therefore, augmented to $182\frac{1}{2}^{0}$ in the course of a whole year. This annual accession of heat, however, is quickly dispersed by the mobility of the fluid medium, and gradually absorbed into the earth, or more quickly diffused through the waters of the ocean, which, besides, occupy at least three-fourths of the whole surface of our globe. The luminous matter, communicated by the incessant shining of the sun, whether received on the ground, or intercepted in its passage through the air, would hence be capable of communicating one centesimal degree of heat to the body of the earth in the space of 1323 years; a quantity too small, perhaps, to be yet perceived, though its influence may be afterwards detected by very delicate observations.

It is easy to demonstrate, from the laws of optics, that the quantity of light which falls on a horizontal surface must be proportional to the sine of its obliquity. Hence the aggregate light received under the equator at either equinox, is to what would accumulate during twenty-four hours, if maintained at its highest intensity, as the diameter to the circumference of a circle. This daily accession of heat, confined to the mass of atmosphere, would, therefore, in that climate and season, amount to 633 thousand parts of a degree. At the pole itself, during the complete circuit of the sun in midsummer's day, the measure of heat would be about a fourth part greater, or 797 thousand parts; the continued endurance of the sun above the horizon more than compensating for the feebleness of his oblique rays.

In general, the quantity of light received at any place from the sun in the space of one day is denoted by the product of the sine of the semidiurnal arc, or the distance from noon to the time of sunsetting, into the cosines of the latitude and declination, joined to the product of that arc itself into the sines of the latitude and declination; the latter part of the expression being considered as additive or subtractive, according as the declination lies on the same or on the opposite side of the latitude. Hence, at Edinburgh, in the latitude of 56°, the heat collected during one day at the summer solstice is 307 thousand parts, but at the solstice of winter only 166

If a calculation be instituted for the quantities of heat during the half yearly periods, from the equinox of spring to that of autumn, and from the autumnal equinox again to the vernal, the following table will be formed.

	Summer.	Winter.	Whole Year.
Equator . . .	116°	116°	232°
Tropic . . .	127	87	214
Latitude 45° .	120	42	162
Arctic circle .	102	12	114
Pole	84	00	84

The annual accumulation at the latitude of 45° is thus 162°, which differs very little from 158°, the mean between the calorific effects at the equator and at the pole. It may be observed likewise, that the effects vary more slowly at the extremes than near the middle of the quadrant Thus, from the equator to the tropic, and from the arctic circle to the pole, the differences are 30° and 28°; but in the narrower intervals, from the tropic to the latitude of 45°, and thence to the arctic circle, the differences are 52° and 48°. The property now stated corresponds with the changes of mean temperature in different latitudes.

If a current of air from the equator, having the ordinary temperature of 29°, were supposed to travel to the pole, from which an equal and contrary current would consequently flow towards the equator, each journey would transport ·58 degrees of heat. Between two and three such journies performed every year, would therefore be sufficient to disperse the whole accumulation of 148°. This only requires the existence of a wind advancing northwards at the rate of 46 miles every day. It is not necessary even that the wind should either continue permanent, or blow directly north. The same effect would be produced, if it were to blow indifferently to every point of the compass, and only at the rate of three miles an hour; a supposition which agrees perfectly with actual observation.

The circulation excited in the body of our atmosphere thus prevents the heat shed by the sun on different parts of the earth's surface from an excessive accumulation. In proportion as the equatorial regions grew warmer from the predominance of illumination, the polar wind would rush with more rapidity, till it had tempered the excess. This balance of the accession, and the consequent dispersion, of heat, has probably been long attained, and it now regulates the gradation of climates in successive latitudes. But if air had possessed the capacity for heat which belongs to hydrogen gas, it would have produced a more equable diffusion of temperature, insomuch that the temperature of the equator could not have become ten degrees warmer than that of the poles. On the contrary, had our atmosphere been less fluid, or less capable of containing heat, the inequality of different climates would have risen to a higher pitch. That variety of temperature which occurs at present on the surface of the globe, was requisite for the developement of the different vegetable tribes which clothe it. The same harmony connects the system of this lower world which irradiates the expanse of the celestial regions.

The equilibrium of temperature preserved over the globe by the circulation of the atmosphere, is not, however, very quickly produced. Hence the remarkable increase of heat which takes place during the summer months in the higher latitudes. But within the arctic circle, another powerful agent of Nature, is constantly tempering the inequality of the seasons. The vast beds of snow or fields of ice which cover the land and the sea in those dreary retreats, absorb, in the act of thawing or passing again to the liquid form, all the surplus heat collected during the continuance of a nightless summer. The rigour of winter, when darkness resumes her tedious reign, is likewise mitigated by the warmth

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evolved as congelation spreads over the watery surface.

Of the light received from the sun, which, by its union with other bodies, constitutes heat, a considerable portion is always detained and absorbed, in its passage through the atmosphere. Even a vertical ray shot through the clearest air, will lose more than the fifth part of its intensity, before it reaches the surface of the earth. In most cases, the loss which light will suffer in the shortest transit through the atmosphere, may be estimated at one fourth of the whole. But the oblique rays must undergo a much greater absorption. If, from their slanting course, they have to encounter twice the number of aërial particles, their intensity must be reduced to nine-sixteenths or the square of three-fourths; and if they describe triple the vertical tract, only twenty-seven sixty-fourth parts, or the cube of three-fourths, will reach the ground. In general, if the tracts of light follow an arithmetical progression, the diminished force with which it escapes and arrives at the ground, will form a decreasing geometrical one. To determine the train of aërial particles which the oblique rays of the sun must traverse in their passage through the atmosphere, is a nice problem, which requires a skilful application of the integral calculus. Without stopping to engage, at present, in the details of this intricate investigation, it may suffice to remark, that, in general, the length of the tract is nearly in the inverse ratio of the sine of the sun's altitude. But the following table, to every five degrees, is calculated from rigorous formulæ, the length of oblique tract being reduced to the same standard of air uniformly dense. These quantities again are diminished in the ratio of the sine of obliquity, to express the calorific action which those enfeebled and slanting rays finally exert at the surface of the earth.

Sun's Altitude.	Measure of Atmospheric Tract.	Intensity of the Light Transmitted.	Calorific Action at the Surface.
90°	1.000	.750	.740
85	1.004	.749	.747
80	1.015	.747	.735
75	1.035	.742	.717
70	1.064	.736	.691
65	1.103	.728	.660
60	1.154	.718	.609
55	1.220	.704	.577
50	1.305	.687	.526
45	1.413	.666	.454
40	1.554	.640	.411
35	1.740	.606	.348
30	1.995	.563	.282
25	2.359	.507	.214
20	2.905	.434	.148
15	3.841	.331	.086
10	5.610	.199	.035
5	10.450	.050	.004
0	37.850	.00002	——

It hence appears that, even when the sky is most serene, only one-half of the sun's light can reach the surface of the earth from an altitude of 25°, or one-third from that of 15°, and that, if the obliquity of the rays were increased to 5°, no more than the twentieth part of them would actually be transmitted. The annual quantity of light which falls may be computed as equivalent at the equator to an uniform illumination from an altitude of 17° 46′; and, in the mean latitude of 45° and at the pole, the effects are the same as if the rays had respectively the constant obliquities of 13° 2′ and 7° 17′. Wherefore, under the most favourable circumstances, of 1000 parts of light transmitted from the sun, only 378 can, at a medium estimate, penetrate to the surface at the equator, 228 in the latitude of 45°, and 110 at the pole of their oblique rays; but the shades received by a given portion of the surface are still less, being only 115, 51, and 14. In cloudy weather, the portion of light that can finally reach the ground will seldom amount to the third of those quantities; and when the sky becomes darkened with accumulated vapours, almost every shining ray is intercepted in its passage.

Influence of the Sun's Rays upon Seas and Lakes.

The light which at last gains the surface being there absorbed and converted into heat, is, in this form, profusely delivered to the ambient air, or more feebly conducted downwards into the body of the earth. But the rays which fall on seas or lakes are not immediately arrested in their course; they penetrate always with diminishing energy, till, at a certain depth, they are no longer visible. This depth depends, without doubt, on the clearness of the medium, though probably not one tenth part of the incident light can advance five fathoms in most translucid water. The surface of the ocean is not, therefore, like that of the land, heated by the direct action of the sun during the day, since his rays are not intercepted at their entrance, but suffered partially to descend into the mass, and to waste their calorific power on a liquid stratum of ten or twelve feet in thickness.

But the surface of deep collections of water is kept always warmer than the ordinary standard of the place, by the operation of another cause, arising from the peculiar constitution of fluids. Although these are capable, like solids, of conducting heat slowly through their mass, yet they transfer it principally in a copious flow by their internal mobility. The heated portions of a fluid being dilated, must continue to float on the surface; while the portions which are cooled, becoming consequently denser, will sink downwards by their superior gravity. Hence the bed of a very deep pool is always excessively cold, since the atmospheric influences are modified in their effects by the laws of statics. The mean temperature of the climate is not communicated by those variable impressions; every change to warmth being spent on the upper stratum, while every transition to cold penetrates to the bottom, which thus experiences all the rigours of winter, without receiving any share of the summer's heat. But, if the beds of profound bodies of water remain perpetually cold, their surface undergoes some variety of temperature, and is generally warmer than the average weekly or monthly heat of the air.

These principles are confirmed by observations made on our own lakes, and strikingly exemplified in

those of Switzerland, which have a breadth proportioned to the stupendous altitude of their circling mountains. It appears, from the careful observations of Saussure, that the bottoms of those majestic basins, whether situate in the lower plains, or embosomed in the regions of the upper Alps, are almost all of them equally cold, being only a few degrees above the point of congelation. That accurate observer found the temperature of the Lake of Geneva, at the depth of 1000 feet, to be 42°, and could discover no monthly variation under 160 feet from the surface. In the course of July, he examined the Lakes of Thun and Lucerne; the former at the depth of 370, and the latter at that of 640 feet, had both the temperature of 41°, while the superficial waters indicated respectively 64° and 68½°, by Fahrenheit's scale. The bottom of the Lago Maggiore, on the Italian side of the Alps, was a little warmer, being 44° at the depth of 360 feet, while the surface was almost as high as 78°. Barlocci has since found that the Lago Sabatino, near Rome, at the depth of 490 feet, was only 44½°, while the thermometer, dipped at the surface, marked 77°.

Through the friendship of Mr James Jardine, Civil Engineer, we are enabled to give the results of his observations on some of the principal Scottish lakes, which, as might be expected from him, were conducted with the most scrupulous accuracy. The instrument which he employed for exploring the temperature at different depths, was free from the ordinary objections; being a register thermometer, let down in a horizontal position, which could acquire the impression in not many seconds, and might be drawn up leisurely, without risk of subsequent alteration. It would appear, that the variable impressions of the seasons do not penetrate more than 15 or 20 fathoms; that, below this depth, an almost uniform coldness prevails. Thus, in the deepest part of Loch Lomond, on the 8th September 1812, the temperature of the surface was 59°.3 of Fahrenheit; at the depth of 15 fathoms 43°.7; at that of 40 fathoms 41°.3; and, from that point, to about 3 feet from the bottom, at 100 fathoms, it decreased only the fifth part of a degree. Again, on the preceding day, the superficial water of Loch Katarine being at 57°.3, the thermometer, let down 10 fathoms, indicated 50°.6; at the depth of 20 fathoms it marked 43°.1; at the depth of 35 fathoms it fell to 41°.1; and on the verge of the bottom, at 80 fathoms, it had only varied to 41°. At the same place, on the 3d September 1814, the heat of the surface was 56°.4; at the depth of 10 fathoms 49°.2; at that of 20 fathoms 44°; at that of 30 fathoms 41°.9; and at that of 80 fathoms 41°.3.

Hence it is that, even in the northern latitudes, the deep lakes are never, during the hardest winters, completely frozen over. But if the same water be let into a shallow basin, it will, in a rigorous season, be chilled thoroughly, and converted into ice. This may even happen when spread above the surface of salt water, which is always considerably denser. Thus, frost takes no effect on Loch Ness, nor on the river of that name, which, in a rapid course of a few miles, discharges the surplus water into the sea. But in very severe winters, a sheet of ice appears formed along the shore; the impressions of cold being almost wholly expended on the accumulation of fresh water, since the chilled portions of this which continually descend are stopped in their progress by the greater density of the recumbent sea water.

The seas and the ocean itself obey the same law of the distribution of heat; only the difference of temperature experienced by sounding in the Mediterranean is less conspicuous than in the fresh-water lakes. Saussure found the temperature at the bottom, in the Gulfs of Nice and of Genoa, at the depths of 925 and of 1920 feet, was the same, or 55°.8, the heat of the superficial water being about 69°. But the mean temperature, or that of the body of the land on the same parallel of latitude, is 59°. The smallness of the diminution here observed may perhaps be attributed to the effect of evaporation in such hot confined bays, the water at the surface being thus rendered salter, and consequently disposed, by its acquired density, to sink into the colder mass below.

In open seas, and in damper climates, the depression of temperature is greater in the inferior strata. This difference becomes augmented in proportion of the extreme variation of the seasons. Lord Mulgrave, on the 4th September 1773, in the latitude of 65° north, drew up water from the depth of 4100 feet, which he found to have the temperature of 40°, while the thermometer, dipped at the surface, stood, on the 19th June, at 55°. In the latitude of 66°, a register thermometer, let down 4680 feet, marked 26°, while the air was at 48½°; and on the 31st August, in the latitude of 69°, while the exterior thermometer indicated 59½°, the temperature of the water at the depth of 4040 feet was only 32°. In shallow seas, the two extremes are brought closer together, and therefore a similar difference of temperature now occurs at moderate depths. The water lying on the surface, which, in the vicissitude of the season, comes to be chilled, is not precipitated as before to a fathomless abyss. The increase of cold below is hence considered as an indication of the proximity of banks, if not of the approach to land itself.

A like gradation of temperature is produced by the alternating influence of the seasons in deep and stagnant masses of air. When this active fluid is confined in profound caverns, opening to the sky without being much exposed, and either perpendicular or gently inclined, its lower strata become intensely and permanently cold. The mild air of summer floats motionless at the mouth of the pit; but, in winter, the superior air, cooled many degrees perhaps below the freezing point, and therefore greatly condensed, precipitates itself continually to the bottom.

This fact takes place in most caverns, and in draw-wells which are left uncovered. Saussure found, on the first of July, when the thermometer in the shade stood at 78° of Fahrenheit, that a cave in the Monte Testaceo, a small hill in the vicinity of Rome, formed entirely by the enormous accumulation of broken pottery, had the temperature of 50°; and two other caves in the same porous mass cooled to 44°. On the 9th July, when the external air was at 61°, the cave of St Marino, at the foot of a sandstone hill, about 2080 feet above the level of the sea, indicated only 44½,

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which is 8° degrees below the mean temperature of the soil in that situation. In the grotto of Ischia, and in the caves of Cesi and of Chiavenna, the thermometer marked likewise $44\frac{1}{2}^0$; but, in the caves of Caprino, on the borders of the Lake of Lugano, it stood at different times of the year at 37^0, and at 42^0; and in those of Hergisweil, near Lucerne, the heat of the interior, on the 31st of July, was only $39\frac{1}{2}$.

But this phenomenon is still more striking in certain peculiar circumstances. The famous Swedish mine of Dannemora, which yields the richest iron ore in the world, presents an immense excavation, probably two or three hundred feet in depth. On the occasion of some repairs, which suspended the usual labours, the basin appeared some years since full of water, with huge blocks of ice floating in it.—The silver mine of Kongsberg in Norway has for its main shaft a frightful open cavern, perhaps three hundred feet deep, and thirty feet wide, of which the bottom is covered with perpetual snow.—Hence, likewise, on the sides of Ætna and of the mountains in Spain, the collected snows are preserved all the year in caves and crevices of the rocks, from which natural stores the muleteers carry down, during summer, to the villages and the cities of the plain, a material so necessary to comfort in those parched climates.

Absolute quantity of Heat the same at every Elevation.

Such is the disposition induced in a confined column of air; but, in a free atmosphere, the gradation of temperature is exactly reversed, the lower strata being invariably warmer than the upper. This most important fact in meteorology and physical geography was thought sufficiently explained in the infancy of physical science, from the proximity of the heat supposed to be reflected by the surface of the earth. But it were idle to attempt any serious confutation of such crude ideas. The true cause of the cold that prevails in the higher regions of the atmosphere, is undoubtedly the enlarged capacity which air acquires by rarefaction. From the unequal action of the sun's rays, and the vicissitudes of day and night, a quick and perpetual circulation is maintained between the lower and the upper strata; and it is obvious that, for each portion of air which rises from the surface, an equal and corresponding portion must likewise descend. But that which mounts up, acquiring an augmented attraction for heat, has its temperature proportionally diminished; while the correlative mass falling down, carries its share of heat along with it, and again relaxing its attraction, seems to diffuse warmth below. A stratum at any given height in the atmosphere is hence affected both by the passage of air from below and by the return of air from above, the former absorbing a portion of heat and the latter evolving it. But the mean temperature at every elevation is on the whole still permanent, and, consequently, those disturbing causes must be exactly balanced, or the absolute measure of heat is the same at all heights, suffering merely some external modification from the difference of capacity in the several portions of the fluid with which it has combined. That temperature is hence inversely as the capacity of air having the rarity due to the given altitude.

Investigation of the increased Capacity of Rarified Air.

It only remains, therefore, to discover the capacity of air, or its attraction for heat under successive pressures, or at different degrees of rarity. But this problem requires a very nice investigation, and appears incapable of being resolved by any direct procedure. If the elaborate experiments of Dr Crawford and others on the capacity of air in its ordinary state, gave such erroneous results, what hope could be formed of ascertaining even its minute shadings by any similar plan of operation? Fortunately, independent almost of any theory, a simple method occurs for conducting this research. A delicate thermometer, suspended within the receiver of an air-pump, indicates a decrease of temperature, as the process of rarefaction advances. But, on stopping this operation at any stage, the thermometer will slowly regain its former state. If now, when the equilibrium is restored, the air be suddenly readmitted, the dilated portion which had remained in the receiver, liberates the heat absorbed by it during the progress of rarefaction. The thermometer, accordingly, rises quickly through a certain space, then becomes, for a short while, stationary, and afterwards slowly subsides. But the instrument does evidently not measure the whole of the heat thus evolved, a great part of it being spent in warming up to the same point the internal surface of the receiver This action, however, is merely superficial, since its effect appears to be momentary. Consequently, the internal surface of the receiver, with that of the plate on which it stands, as penetrated by the sudden impression to a certain very minute depth, forms a constant film of matter, which, as well as the body of air itself, draws its supply from the extricated heat. Under the same receiver, therefore, although the air will not seize the whole of the heat disengaged in the act of admission, it must always retain a proportional share of it. A series of experiments, at successive degrees of rarefaction, must hence discover, if not the absolute, yet the relative, changes of the air's capacity for heat.

Details of the Experiment.

To institute this inquiry with the desired success, an excellent and powerful air-pump was used, having a receiver of the very largest dimensions, of an oblong spheroidal form, approaching, however, nearly to the globular, and with a narrow bottom. The apparatus being placed in the middle of a close room, which had a steady temperature, a thermometer with a slender stem, open at top, and a small bulb of extreme sensibility, was fixed in a vertical position, a few inches above the centre of the plate. Having replaced the receiver, and allowed it to stand some time, one-fifth of the air was now extracted from under it; and, after a considerable interval, the cock was suddenly opened, to restore the equilibrium; and the mercury of the thermometer, which had been stationary, mounted up very rapidly 3.0 centesimal degrees, from which point it afterwards slowly descended.

The temperature of the room having been regained, two-fifths of the air in the receiver was then extracted; and, after some lapse of time, the external

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communication being repeated, the thermometer rose instantly 5.3 centesimal degrees. On extracting three-fifths of the internal air, the corresponding ascent of the thermometer, at the restoration of the equilibrium, was 7.0 of those degrees; and, when the contents of the receiver had been rarefied five times, the heat evolved, on the re-admission of the air, amounted to 8.0 degrees. The rate of progressive effect was thus evidently diminishing. On pushing the rarefraction as far as it was really practicable, or till the residual air had become rarefied about 300 times, the change indicated by the thermometer did not reach to more than 8.3.

But, to determine the absolute quantity of heat which is disengaged in the transition of air from a rarer to a denser state, it becomes necessary to ascertain what part of it was consumed on the sides of the receiver. By varying the size of the receiver, and consequently altering the proportion between its surface and its contents, some light may be thrown on this question. Another similar receiver was therefore provided, having half the former dimensions; and with this the same set of experiments was repeated. Its included air being reduced successively to the density of four-fifths, three-fifths, two-fifths, and one-fifth, and then rarefied as much as possible, the thermometer mounted each time through the shorter spaces of 1.8, 3.2, 4.2, 4.8, and finally 5.0 centesimal degrees. These quantities evidently follow the same proportion as the former, of which indeed they are only three-fifths. But the smaller receiver, having, under the fourth part of the surface of the larger, only the eighth part of its contents, exposes comparatively twice the extent of surface. The rise of temperature which its included air exhibits, must consequently be the same as what would have obtained within the larger receiver, if, while its capacity remained the same, its surface had been actually doubled. If we suppose the air to hold one part of the heat, while two parts and four parts are respectively expended on the insides of the receivers, the results would correspond with observation; for the whole quantity evolved, being in both cases the same, the air under the larger receiver would retain one third, and, under the smaller receiver, only one-fifth; the impressions being thus in the ratio of five to three. The same conclusion may be obtained somewhat differently. If the heat spent on the inside of the large receiver had been spread over twice the surface, it would have raised the temperature only $1^0.5$; but this mounted really to $1^0.8$, and therefore the difference .3 was the effects of $1^0.8$, derived from the contained air. Of the heat thus shared between the air and the doubled surface, one part was hence retained, and five communicated. Consequently, to obtain the true results, it is only necessary to multiply the second set of quantities by five, or the first set by three. If no waste, therefore, took place against the inside of the receiver, the heat evolved in the passage of air from the densities of four-fifths, three-fifths, two-fifths, one-fifth, and extreme rarefaction, to its ordinary state, would be 9, 16, 21, 24, and 25 centesimal degrees.

Inferences.

It is not difficult to discover the law of this progression. They are obviously formed by the successive addition of the odd numbers 9, 7, 5, 3, and 1; and are, consequently, the excesses of the square of 5 above the squares of 4, 3, 2, and 1. Wherefore, if the square of the density be taken from unit, the remainder, multiplied by 25, will express in centesimal degrees, the rise of temperature which accompanies the return of the air to its ordinary state.

The numbers thus obtained, however, do not still express the final results. If the restoration of four parts of the air included under the receiver to their usual density, disengage heat, sufficient to raise the temperature of the whole five parts 9 degrees, its real measure must have been $11\frac{1}{4}$ degrees, or the former augmented in the ratio of 4 to 5. For the same reason, if three-fifths, two-fifths, and one-fifth of the air in the transition of density, evolve portions of heat, which would elevate the temperature of the mass 16, 21, and 24 degrees, the actual quantities are $26\frac{2}{3}^0$, $52\frac{1}{2}^0$, and 120^0, or those numbers multiplied by 5, and divided by 3, 2, and 1.

General Conclusion.

These conclusions are easily reduced to formulæ. Let θ denote the density of the air, and $25\,(1-\theta^2)$ will express, in centesimal degrees, the elevation of the thermometer which would follow the readmission of the air, if none of the heat were spent on the inside of the receiver. Consequently, $25\left(\frac{1-\theta^2}{\theta}\right)$, or $25\left(\frac{1}{\theta}-\theta\right)$, will exhibit, on the same scale, the whole quantity of heat evolved in the restoration of density. The last formula is extremely simple, implying that 25, multiplied into the difference between the density of air and its reciprocal, will represent the measure of heat due to the change of condition. This result may be either additive or subtractive; it may express the heat emitted in the condensation of air, or the heat absorbed during its opposite rarefaction.

Application of the Formula.

Thus, the heat extricated from air which has its density doubled is $25^0\,(2-\frac{1}{2})$, or $37\frac{1}{2}^0$; and the same quantity is withdrawn, either when this air recovers its former density, or when air of the ordinary state expands into double its volume. Hence the copious heat extricated by the sudden compression of air. If it were condensed thirty times, the heat discharged would amount to $25\left(30-\frac{1}{30}\right)$, or 749^0, which is more than sufficient for the inflammation of fungous or soft substances. On this principle, are constructed the pneumatic matches lately invented by Mollet of Lyons, which produce their effect by the momentary action of a small syringe.

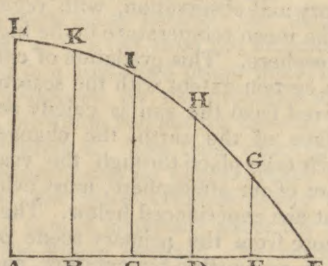
But, to discover the relative capacity or attraction which air of a given density has for heat, it would be necessary to know the extent of the natural scale, or the position of the absolute zero. The conclusions, however, from different data, are not very constant; yet several experiments appear to fix nearly the point from which the infusion of heat commences at 750 centesimal degrees below congelation. On this supposition, therefore, air which is rarefied thirty

times has its capacity doubled, the heat contained in it being dilated only fifteen times. For the same reason, air sixty times rarer than ordinary acquires a triple attraction for heat, which, in this union, becomes attenuated only twenty times. But these inferences are merely speculative, and the law of the gradation of temperature in the atmosphere is quite independent of the existence of an absolute term of heat.

The last formula now investigated has been already laid before the public, without any explication, however, or indeed indication, of the process by which it was discovered. The experiments on which it rests were begun many years since, and have been repeated with every precaution. But the mean results only are retained; and, for the sake of simplicity, a few slight modifications have been introduced, to adapt the apparatus to more convenient proportions. Though it was impossible to blow a receiver that should have *exactly* half the dimensions of another, nothing seemed easier, from the general mode of investigation, than to apply the minute corrections which any small deviations of size or form required. The mixture of obscure and intricate computations has been thus avoided.

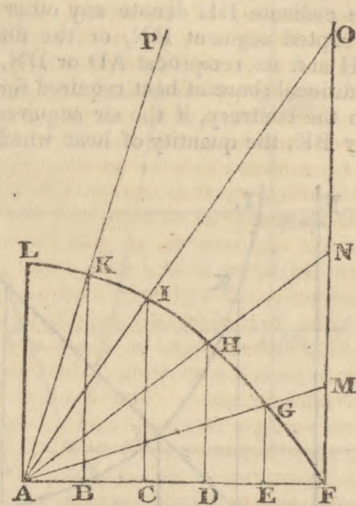
Gradation of Effects represented by a Parabola.

The gradation of the effects disclosed by this experimental research, is more easily and clearly traced in geometrical diagrams. Having divided the abscess AF into five equal portions, erect the several perpendiculars EG, DH, CI, BK, and AL, equal respectively to 9, 16, 21, 24, and 25 parts on any scale, and connect the points F, G, H, I, K, and L, by a curve line. It is readily perceived, that the curve now traced must be a parabola, formed on the axis LA. Wherefore, if AF represent the height of the barometric gage of the air-pump, and AD its altitude after a partial exhaustion, the parallel DH will express the rise of the included thermometer on the re-admission of the air which had been extracted. The axis AL itself denotes the extreme effect, or what would take place if the rarefaction were pushed to the utmost. While the mercurial column, therefore, descends by equal intervals to E, D, C, B, and approximates to A, the elevation of the thermometer through the spaces EG, DH, CI, BK, and nearly AL, advances at first uniformly, and afterwards continually more slowly, till it becomes stationary.



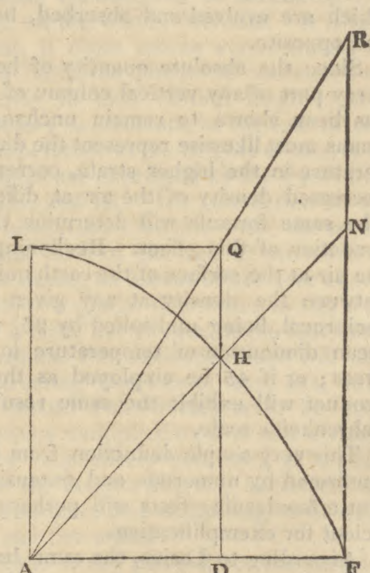
Difference of Temperature produced by the change of the Air's density.

But the parallels to the axis of a parabola, do not express the whole of the heat disengaged by the attenuated air during the resumption of its density. The line DH, for instance, marks only the rise of temperature communicated to the entire mass AF, by the heat evolved from the portion AD; and to represent the true measure of this heat, it must, therefore, be increased in the ratio of AD to AF. Hence, from the point A, and through the extremities of the parallels EG, DH, CI, and BK, draw the oblique lines AG, AH, AI, and AK, to meet the extended perpendicular FO; the intercepted segments or parabolic tangents FM, FN, FO, and FP, (if this last were completed,) will exhibit the real portions of heat liberated from any of the corresponding densities AE, AD, AC, AB.



Farther Illustration.

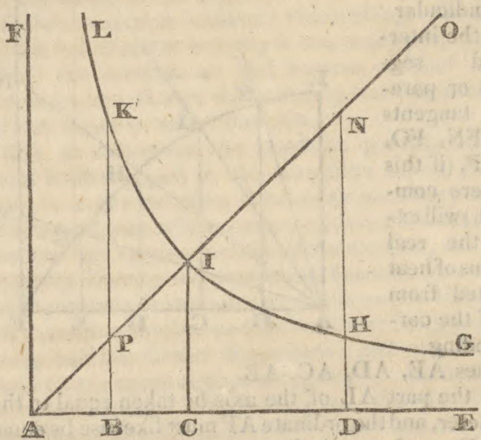
Let the part AL of the axis be taken equal to the parameter, and the ordinate AF must likewise be equal to it: Draw the vertical tangent LQ meeting the parallel DH in Q, join the oblique line AD, and produce it to meet the perpendicular in R. From the property of the curve, QH : AD :: AD : AF; but from the mutual relation of the diverging lines AN, AR, and the parallels DQ and FR, AD:AF:: AH:AN::QH: NR; whence QH:NR::QH: AD, and, therefore, NR is equal to AD. Consequently FN, which expresses the whole evolution of heat corresponding to the density AD, is equal to the difference between AD and FR. But since AD : AF:: DQ or AF:FR, the line FR is the reciprocal of AD, the parameter AF being considered as unit. The measure of heat evolved, or the parabolic tangent FN is, therefore, as before expressed, by the difference of the density of the air and its reciprocal.



The same result may be represented geometrically in another way. Let LIG be a rectangular hyperbola referred to its asymptotes AE and AF, the axis being AO: If the perpendicular IC, or the ab-

sciss AC express the ordinary density of the air, and the ordinate DH denote any other density, the intercepted segment HN, or the difference between DH and its reciprocal AD or DN, will exhibit the additional share of heat required for its constitution. On the contrary, if the air acquires the higher density BK, the quantity of heat which it must evolve

Difference of Temperature exhibited.



in its transition will be represented by KP. In the figure here annexed, the air is presumed to have its density reduced to the half in one case, and doubled in the other, the quantities of heat, HN and KP, which are evolved and absorbed, being then equal and opposite.

Since the absolute quantity of heat contained in every part of any vertical column of the atmosphere has been shown to remain unchanged, these diagrams must likewise represent the diminution of temperature in the higher strata, corresponding to the decreased density of the air at different elevations. The same formula will determine the measure and gradation of this effect. Reckoning the density of the air at the surface of the earth unit, the difference between the density at any given altitude and its reciprocal, being multiplied by 25, will express the mean diminution of temperature in centesimal degrees; or if 45 be employed as the multiplier, the product will exhibit the same result in degrees of Fahrenheit's scale.

This very simple deduction from theory, is amply confirmed by numerous and extensive observations. But a few leading facts will perhaps be deemed sufficient for exemplification.

Examples of the application of the Formula:

According to Lasius, the same barometer, which, at Goslar, an ancient town seated in the bosom of the Hartz Forest, stands at 29,500 inches, would fall to 26,444 on the top of the Brocken, in that Mining District. This gives .896 for the density of the air on the summit, the reciprocal of which is 1.116; but $1.116 - .896 = .22$, and $.22 \times 25^0 = 5^0.5$, the calculated difference of temperature. The actual difference is very nearly the same, being only $5^0.2$; as we had once an opportunity ourselves of observing, having found the temperature of a copious spring at Goslar to be 8 centesimal degrees, while that of the noted Hecken-Brunnen, or *Witch-Well*, on the summit of the Brocken, was only $2^0.8$.

Saussure, whose accuracy always inspires confidence, found that, while at his villa of Conche, near Geneva, the barometer stood at 28.500, another similar instrument fell to 25.165, on the top of the mountain of Nant Bourant. The diminished density of the air at this elevation was, therefore, .890; the difference between which and its reciprocal 1.123 being multiplied by 25^0, gives $5^0.82$. But a thermometer, buried a whole night at two feet deep, in that lofty station, marked only $12^0.75$; while it indicated 6.25 more, or 19^0, a few days afterwards, when sunk to the same depth at Conche. The discrepancy here is thus less half a degree.

To the Temperature of the Ground:

On the top of a higher mountain, the Chapieu, the same observer found the ground, at a depth of two feet, to be colder by $6^0.44$ than at Conche. But the corresponding density of the air and its reciprocal were 872 and 1.147; consequently, $25^0 \times .275 = 6^0.87$.

While the barometer at Conche stood at 28.500 inches, the mercurial column was only 19.836 inches on the summit of Mont Cervin, a still loftier mountain. The density of the air at this elevation was therefore .696; which being taken from its reciprocal 1.437, leaves 741 to be multiplied by 25^0, indicating $18^0.52$ as the diminution of temperature. The actual medium difference ascertained from corresponding thermometrical observations, made at depths in the ground, from one to three feet, on the top of Mont Cervin and at Conche, was $18^0.25$, almost exactly the same.

Such is the nice agreement on the whole, between theory and observation, with regard to the decrease of the mean temperature in the higher regions of the atmosphere. This gradation of cold varies, however, to a certain extent with the seasons. Since the heat derived from the sun is chiefly accumulated at the surface of the earth, the changes of temperature which take place through the year in the elevated strata of our atmosphere, must evidently be less than what are experienced below. The lofty tracts of air, remote from the primary scene of action, preserve nearly an equable temperature, and scarcely feel the extreme heat of summer or winter's frost. In ascending the atmosphere, the decrease of warmth is hence more rapid in the fine season, and more slow in the darkened period of the year. In many places, it will not be far from the truth, perhaps, to assume 30^0 for the multiplier during the summer months, and only 20^0 during those of winter.

And to that of the Atmosphere.

Thus, General Roy, a diligent and experienced observer, found, in the month of August, the air on the top of Snowdon was, in the course of a whole day, at an average 7.2 centesimal degrees colder than on Carnarvon Quay. But the difference between the density at that elevation, and its reciprocal, or between .878 and 1.139 being only .261, would require nearly 28 for the multiplier.

In the early part of September, the same observer noticed the centesimal thermometer to stand 10 degrees lower on the top of Ben Lawers than at Weem, the relative density of the air at that height being .868. The difference from its reciprocal is .284,

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which would hence require to be multiplied by 35 to give the actual diminution of temperature.

Again, Saussure found, on his visit to Mont Blanc, the air on its summit to be 31 centesimal degrees colder than at Geneva. The relative density was .592, which being taken from its reciprocal 1.689, leaves 1.097; consequently, the multiplier required is 28.

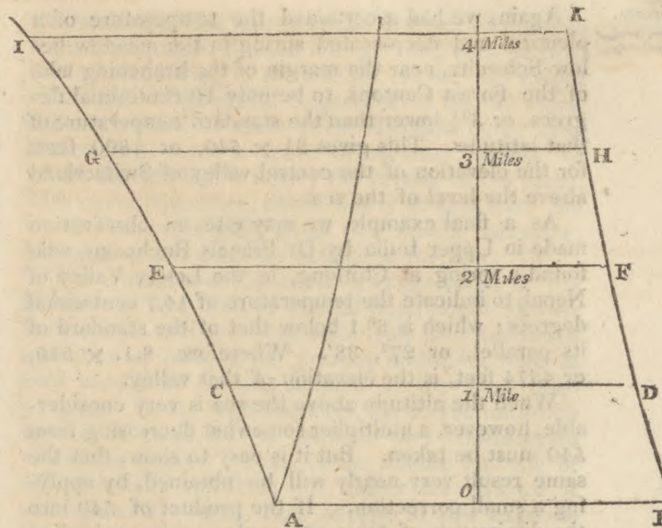
This ingenious philosopher passed several days encamped on the Col du Geant, where he found, from the mean of eighty-five observations, the temperature of the air to be only 4°.54, or 20°.3 colder than at Geneva. But the relative density of that elevated stratum and its reciprocal were .704 and 1.420; the difference of which, or .716, would require to be multiplied by $28\frac{1}{2}$, to indicate the diminished temperature.

The observations made on the decreased temperature of the higher regions of the atmosphere by the ascension of balloons, appear generally to indicate rather a slow rate of diminution. But it should be recollected that those daring aërial flights have seldom been performed except in the fine season of the year. Besides, the car, the balloon, and its cordage, will not immediately acquire the temperature of the elevated strata, but continue for a considerable time to diffuse a sensible portion of heat. A memorable example, however, is entirely conformable to the general principle. Charles, the first who ascended the atmosphere by means of a balloon filled with hydrogen gas, found, on the 1st of December 1783, the thermometer depressed 11 centesimal degrees at the greatest elevation, the column of the barometer having sunk from 29.24 to 20.05 inches. This would require a multiplier less than 20.

Diminution of Temperature in the higher Elevations.

In ascending through equal heights, the density of the atmosphere, as derived from the incumbent pressure, diminishes in a continued proportion. This density is hence represented by the ordinates of a logarithmic curve, of which the absciss denotes the altitude above the surface. The cold which prevails in the upper strata would no doubt modify the dilatation of the air; but, since it follows nearly the same progression, it cannot materially affect the general results. In the figure annexed, the vertical spaces expressing the elevations of one, two, three, and four English miles; the horizontal lines 1D, 2F, 3H, 4K, represent the corresponding mean temperature in the temperate latitudes. But, from the nature of the logarithmic curve, if it were supposed to be continued in like manner below the surface, the horizontal lines at the same equal distances would be the reciprocals of the former. Let this extension of the curve be, therefore, folded back and placed over its first portion, rising from oA, and the difference between the horizontal lines, or the distance between the two branches of the curve, as, from the point A, they constantly spread from each other, will exhibit the diminution of temperature corresponding to the elevation. These branches of the curve at first diverge at the same angle; but the wider branch afterwards spreads with a larger sweep, and their mutual distance slowly increases.

This gradual increasing progression, which marks the diminution of temperature in ascending the atmosphere, is still more apparent from another property of the logarithmic curve. The difference between any two ordinates is constantly proportional to the intercepted area. Consequently, the successive diminution of temperature corresponding to the elevations of one, two, three, or four miles, are expressed by the areas ABDC, CDK, EFHG, and GHKI, But, since the component spaces 0C, 1E, 2G, and 3I, augment evidently faster than 0D, 1F, 2H, and 3K, diminish, the decrements of heat encountered in ascending the atmosphere must, on the whole, increase. It is farther evident, that, if those spaces were reduced to extremely narrow belts, they might be considered as proportional merely to their several lengths; and hence the momentary decrements, or the rate of the diminution of temperature at the heights of one, two, three, and four miles are expressed by the transverse lines CD, EF, GH, and IK. If a calculation be instituted for the temperate climates, while the mean temperature at the level of the sea decreases one centesimal degree during an ascent of 540 feet above the surface, it suffers a similar diminution in 529 feet at the altitude of a mile; but at two, three, four, and five miles of elevation, the same difference will obtain, at the contracting intervals of 498, 454, 401, and 346 feet. Should Fahrenheit's scale be preferred, those numbers multiplied by five, and divided by nine, will give respectively 300, 295, 277, 252, 223, and 192, for the ascents due to a decrement of one degree at the surface, and at the heights of one, two, three, four, and five miles.



The Decrements at first nearly uniform, but afterwards increase rapidly.

Hence the altitude of any place above the surface of the ocean may be nearly ascertained from an observation of its mean temperature. In the milder climates, it will be sufficiently accurate, in moderate elevations, to reckon an ascent of 540 feet for each centesimal degree, or 100 yards for each degree on Fahrenheit's scale, of diminished temperature. Thus, the Black Spring, a copious perennial source which bursts forth on the ridge of the Pentland Hills, in the vicinity of Edinburgh, is found to indicate only 7°.2 centesimal degrees, or 1°.6 less than the medium due to that parallel. But 1°.6 multiplied by 540 gives 868 feet; which differs by a few feet only from the altitude, as determined by actual levelling.

Again, we had ascertained the temperature of a plentiful and deep-seated spring in the meadow below Schweitz, near the margin of the branching lake of the Forest Cantons, to be only 10 centesimal degrees, or $3^0\frac{1}{2}$ lower than the standard temperature of that latitude. This gives $3\frac{1}{2} \times 540$, or 1890 feet, for the elevation of the central valley of Switzerland above the level of the sea.

As a final example, we may cite an observation made in Upper India by Dr Francis Buchanan, who found a spring at Chitlong, in the Lesser Valley of Nepal, to indicate the temperature of 14.7 centesimal degrees; which is $8^0.1$ below that of the standard of its parallel, or 27^0, 38′. Wherefore, $8.1. \times 540$, or 4374 feet, is the elevation of that valley.

When the altitude above the sea is very considerable, however, a multiplier somewhat decreasing from 540 must be taken. But it is easy to show, that the same result very nearly will be obtained, by applying a small correction. If the product of 540 into the diminution of temperature, be again multiplied by the square of this difference in centesimal degrees, and then divided by the constant number 15000, the quotient will express the quantity to be subtracted. Thus, in the last example, the square of 8.1 or 65.61 multiplied into 4374 makes 286978, and this divided again by 15000 gives 18, to be deducted from 4374, leaving 4356 for the corrected altitude.

This correction, therefore, amounts only to $33\frac{1}{2}$ feet at the elevation of one mile; but for two, three, four, and five miles, it would rise to 266, $904\frac{1}{2}$, 2128, and 3350 feet. Though it augments thus rapidly, it may in ordinary cases be totally disregarded, and the allowance of one degree by Fahrenheit's scale for every hundred yards of ascent, is a rule of most easy recollection.

That the decrements of heat, corresponding to equal ascents in the atmosphere, are not uniform, however, but augment gradually with an accelerating progression, is confirmed by the appeal to actual observation. Thus, in proceeding from Geneva to the Vale of Chamouni, through an elevation of 2094 feet, Saussure found the temperature of the air to decrease only $3\frac{1}{4}$ centesimal degrees, or at the rate of one degree in the rise of 644 feet. Between Chamouni and the Col du Geant, an interval of 7940 feet, the diminution of temperature was 17^0, being a degree for each 465 feet of ascent. Again, the summit of Mont Blanc, though only 4400 feet higher than the Col du Geant, was $10^0.8$ colder; which gives a degree for every rise of 407 feet. The acceleration of cold is here very perceptible; but the gradation from Geneva to Chamouni was unusually slow, owing to the position of this sequestered spot, where the action of the sun-beams, in summer, being sheltered from the influence of dispersing winds, accumulates above the standard. Near the level of the sea, the ascent, corresponding to the decrement of a centesimal degree, very seldom exceeds 600 feet.

Height of the limit of Perpetual Congelation in different Latitudes.

Since, in ascending from the surface, the temperature constantly diminishes, there must, in every latitude, exist a certain limit of elevation at which the air will attain the term of congelation. The mountains, likewise, which rear their heads above that boundary, are covered with eternal snow. In the higher regions of the atmosphere, especially within the tropics, the temperature varies but little throughout the whole year. Hence, in those brilliant climates, the line of perpetual congelation is strongly and distinctly marked. But, in countries remote from the equator, the boundary of frost rises after the heat of summer, as the influence of winter prevails,—thus varying its position over a belt of some considerable breadth.

The height of the limit of perpetual congelation for any latitude, is easily determined from the principles already established. Let t denote the mean temperature in centesimal degrees at the surface of the ocean, and x the density of the upper atmosphere at the line, where the reign of frost begins. It is evident from the formula, that $\left(\frac{1}{x} - x\right) 25 = t$; whence $x^2 + .04\,tx = 1$, and this quadratic equation being solved, gives $x = \sqrt{1 + .0004\,t^2} - .02\,t$. From the density of the air thus found, the corresponding altitude is discovered by the application of logarithms, as in the barometrical measurements. Hence the following table is computed:

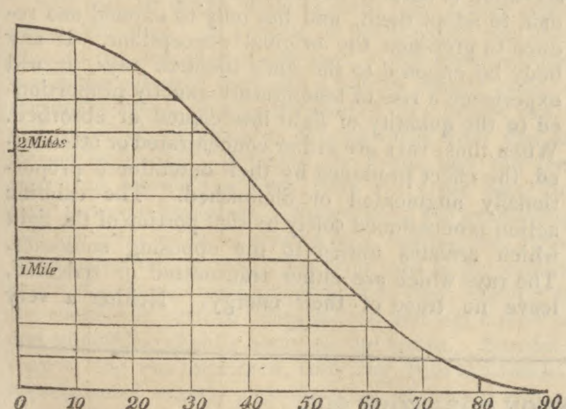
Latitude.	Height of Curve of Congelation. English Feet.	Latitude.	Height of Curve of Congelation. English Feet.
0^0	15207	32°	11018
1	15203	33	10778
2	15189	34	10534
3	15167	35	10287
4	15135	36	10036
5	15095	37	9781
6	15047	38	9523
7	14989	39	9263
8	14923		
9	14848	40	9001
		41	8738
10	14764	42	8473
11	14672	43	8206
12	14571	44	7939
13	14463	45	7671
14	14345	46	7402
15	14220	47	7133
16	14087	48	6865
17	13947	49	6599
18	13798		
19	13642	50	6334
		51	6070
20	13478	52	5808
21	13308	53	5548
22	13131	54	5290
23	12946	55	5034
24	12755	56	4782
25	12557	57	4534
26	12435	58	4291
27	12145	59	4052
28	11930		
29	11710	60	3818
		61	3589
30	11484	62	3365
31	11253	63	3145

Latitude.	Height of Curve of Congelation. English Feet.	Latitude	Height of Curve of Congelation. English Feet.
64	2930	78	656
65	2722	79	552
66	2520		
67	2325	80	457
68	2136	81	371
69	1953	82	294
		83	226
70	1778	84	167
71	1611	85	117
72	1451	86	76
73	1298	87	44
74	1153	88	20
75	1016	89	05
76	887	90	
77	767		

This table, though calculated from theoretical data, will be found to coincide with actual observation. It suggests a variety of important results; and the position of the snowy boundary may direct the intelligent traveller to estimate the elevation of any country. Thus, Ben Nevis, the highest mountain in Scotland, is generally seen covered with snow through the whole year, except during two or three weeks in the month of July. Its summit, therefore, does not reach the limit of congelation, which, at the latitude of 57°, has an altitude of 4534 feet. Accordingly, the height of that mountain is only 4380 feet. Again, we learn from the relations of travellers, that, though perpetual snow covers the stupendous ridge of the Himalaya mountains in Upper India, it descends but a short way along their sides, and leaves, for the *ghauts* or passages below, a grassy plain. But the boundary of congelation traverses the parallel of 30° at the altitude of 11,484 feet, and consequently that towering range may rise probably 4000 or 5000 feet higher, and thus surpass the elevation of Mont Blanc. The pretended altitudes of 23,000 or even 27,000 feet, so recently assigned to those mountains, are hence utterly incredible.

The gradation of altitude which marks the snowy boundary in different latitudes, is most clearly perceived from the inspection of a diagram. Thus, if

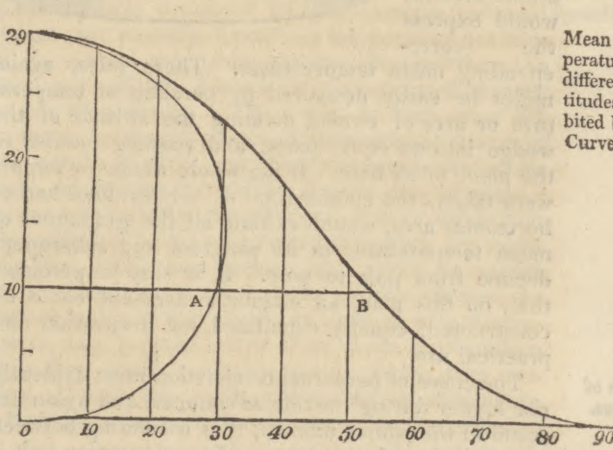
presented a Curve.



the horizontal line represent the distance of the pole from the equator, divided into 90°, and each vertical line corresponding to the latitude denote the height of the limit of perpetual congelation in English miles, the extremities of these perpendiculars being connected, will form a curve of contrary flexure, of which the one half is nearly the reverse of the other. This curve, therefore, bends slowly at first from the equator; most rapidly about the middle latitudes; but again slants near the surface to the pole.

The ordinates of this curve of congelation, or the altitudes of the limit of eternal frost, might also be found, with sufficient precision, from the corrected gradation of cold, if the primary multiplier were in each parallel of latitude adapted to the mean temperature. In the high latitudes, the correction to be applied is small, but it becomes very considerable within the tropics. Thus, in the middle latitude of 45°, it is only 110 feet; but, under the equator, it amounts to 877 feet. But, except in this extreme case, the altitude of the snowy boundary will, on the whole, differ very little from the product of the mean temperature by 540. That line must, therefore, approximate to a coincidence with the curve formed by referring the series of temperatures to the successive latitudes. Let the tangent 0 90 be applied equal to the semicircumference 0 A 29 of a circle, and

Mean Temperature in different Latitudes exhibited by a Curve.



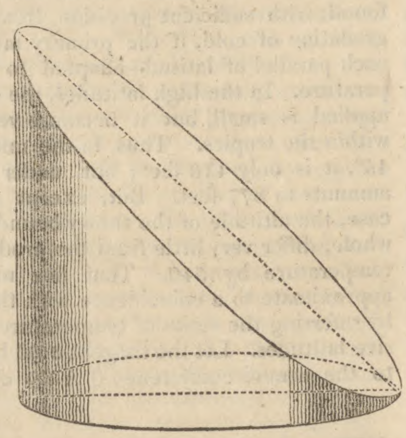
every intermediate point B be determined, by making any parallel 10 AB equal to the intercepted arc A 29. If the absciss then represent the meridian extending from the equator to the pole, the several ordinates will express the corresponding mean temperatures at the level of the sea. The reason of this construction is easily perceived; for the arc 0 A of the generating circle being equal to the complement of the corresponding latitude, its chord is equal to the cosine of this latitude, which belongs to a circle having twice the diameter of the former; but the ordinate from B, or the perpendicular segment 0 10, is proportional to the square of the chord 0 A, and consequently to the square of the cosine of the latitude.

The curve now constructed is what has been called the *Companion of the Cycloid*. In fact, it differs from the cycloid only by the defect of the generat-

Climate.

ing circle. If each parallel AB were extended as far beyond B as 10 A, the cycloid would be traced. This deficient cycloid has obviously the same aspect as the curve of perpetual congelation. It is only less flattened towards the equator, where the correction of altitude chiefly operates. A close inspection, however, is requisite to distinguish their difference.

The companion of the cycloid, or curve of temperatures, might also be formed, by unrolling half the convex surface of a cylindrical wedge or *ungula*. The curve, already delineated, was only the expansion of the annexed figure.



If the semicircumference of the base of the cylinder were divided into 90 equal parts, to denote the successive latitudes from the equator to the pole, the perpendicular lines terminating in the oblique section, would express the corresponding mean temperatures. These lines, again, might be easily measured by parallels of temperature or arcs of circles, dividing the altitude of the wedge into 29 equal parts, and running parallel to the plane of its base. If the whole wedge or ungula were taken, the combination of vertical lines and of horizontal arcs, would exhibit all the gradations of mean temperature, in its progress and subsequent decline from pole to pole. It is easy to perceive, that, on this plan, an elegant instrument could be constructed, equally calculated for illustration and practical use.

Origin of Glaciers.

The curve of perpetual congelation must evidently rise higher during the tide of summer, and again descend in the winter months, thus oscillating between certain limits of elevation. The intervening belt is narrow under the equator; but it enlarges to a very considerable extent in the higher latitudes. On the breadth of this zone, where frost holds a doubtful reign, depends the formation of *glaciers*, along the flanks of the snowy mountains. The fields of snow, which are alternately melted and congealed, become at last changed by this process into solid ice, often grouped and fashioned by such irregular action into the most fantastic shapes. In its native seat, this icy belt acquires continual additions to its height, till the accumulating pressure at last tears the mass from its base, and precipitates its dissevered fragments to a lower level. In its new position, below the inferior boundary of congelation, the enormous pile suffers, on the whole, a very gradual thaw, which is sometimes protracted for several centuries. Meanwhile, in the higher magazine, another icy belt is again slowly collecting, which will in due time repeat the succession, and maintain the eternal circle of production and decay.

Within the tropics, the zone of undecided frost is so very narrow, that scarcely any trace of a glacier has been ever observed. But as that zone enlarges in the higher latitudes, the appearance of vast glaciers constitutes a very striking feature in the aspect of the lofty mountains. They occur frequently along the sides of the Pyrennees; but they are still more conspicuous in the recesses of the central chain of the Swiss Alps. Glaciers are likewise seen as far north as the verge of the Arctic Circle. Along the western shore of Norway, and the coast of Lapland, stretching onwards to the promontory of the North Cape, huge masses of columnar ice descend from the cliffs, or against the precipitous sides of the mountains, almost to the surface of the ocean.

Heat only Light in a Latent Form.

Through the whole train of investigation now pursued, the warmth which vivifies our globe has been viewed as flowing from the fountain of the Sun. The easiest mode of conceiving the subject is to consider the Heat which permeates all bodies, and unites with them in various proportions, as merely the subtle fluid of Light, in a state of combination. When forcibly discharged or suddenly elicited from any substance, it again resumes its radiant splendour. Such changes are exhibited in the phenomena of Electricity, and in many of the operations of Chemistry. But the production of Light is not less striking in the ordinary business of life. The glowing spark struck from flint, and the consuming fire, which even the rudest tribes had learned to excite by the rapid friction of two pieces of dry wood, were by the ancient philosophers regarded as only detached portions of the divine and celestial flame which illumes the empyreal vault. The same notion was embraced by the poets, and gives sublimity to their finest odes. Heavenly Light, Invisible Light, and the Light of Life, * are lofty and refined expressions, which gleam through the mystic hymn of Orpheus.

Those poetical images which have descended to our own times, were hence founded on a close observation of nature. Modern philosophy need not disdain to adopt them, and has only to expand and reduce to precision the original conceptions. If any body be exposed to the sun's incident rays, it will experience a rise of temperature exactly proportioned to the quantity of light intercepted or absorbed. When those rays are either concentrated or attenuated, the effect produced by their detention is proportionally augmented or diminished. The calorific action is occasioned solely by that portion of the light which remains united to the opposing substance. The rays which are either transmitted or reflected, leave no trace of their energy. Neither a very

* ΟΥΡΑΝΙΟΝ ΦΩΣ,—ΑΦΑΝΤΟΝ ΦΩΣ—ΖΩΗΣ ΦΩΣ.

Climate.

bright reflecting surface, nor a fine pellucid medium, is sensibly heated on being exposed even to a meridian sun. But since reflection and transmission cannot be perfect, a certain calorific effect, however small, and varied by circumstances, is always the result. A polished surface of silver may absorb from the tenth to the fifth part of the perpendicular rays; and we have seen that the thin body of atmosphere itself will detain one-fourth part of the vertical light shot down through it, and one half of the beams that slant at an inclination of 25°. The absorption of light in its passage through water is proportionally greater; the perpendicular rays lose half their force by a descent of 17 feet in that medium; become reduced to one-fourth by traversing a path of 34 feet, which corresponds to the mass of an atmosphere. It hence follows, that only the hundred thousandth part of the vertical rays can penetrate below 47 fathoms. But this faint remnant is scarcely equal to the glimmer of the closing twilight. The depths of the ocean are never visited, therefore, by the cheering influence of the great luminary of day.

The rise of temperature produced by the same measure of the absorption of light, is in different substances inversely as their capacity or attraction for heat. Thus, if two very thin glass balls of the same diameter, and coated with China ink, be filled, the one with water and the other with mercury, and exposed to the sun, the latter will mark an accession of five degrees of heat, while the former will indicate only two. Or, if two equal and similar pieces of glass and lead were both of them blackened and presented to the incident solar rays, the lead will acquire a higher temperature than the glass, in the ratio of 12 to 7.

Invisible rays of heat.

This theory agrees, therefore, in all its bearings, exactly with observation. But facts have been alleged, of a contrary tendency; and some ingenious, yet incorrect experiments, performed by a celebrated astronomer, appear to have, for several years, deceived the public into a belief, that, besides the ordinary mixture of coloured rays emanating from the sun, there is emitted also a cluster of invisible and less refrangible rays, which excite or constitute heat.

As if such an hypothesis were not already sufficiently complex, it was afterwards assumed, that there exists likewise another series of dark rays, more refrangible than usual, whose office it is merely to abstract oxygen from the substances on which they fall. But a closer examination of the circumstances have proved, that, in forming these opinions, philosophers have proceeded to generalize too fast. If, while the sky is perfectly clear, which seldom happens indeed in this climate, the solar spectrum formed behind a prism be observed by a differential thermometer in a darkened room, the intensity of the heat will be found to augment most rapidly in passing from the one extremity to the other, from the limit of the violet to that of the red. When a prism of flint-glass was used, we found that the spectrum being divided into four equal spaces, the effects indicated by the thermometer, and corresponding to the range of the violet, the green, the yellow, and the red, were as the square numbers 1, 4, 8, and 16. If the spectrum were formed by another refracting medium, as the intermediate coloured spaces would alter their proportions, so likewise would the calorific action vary. But, in every case, the violet and the red rays which occupy the extremes, must differ very widely in their relative energies. Without the spectrum, however, and beyond the absolute limit of illumination, no sort of action whatever is betrayed. * The distinct effects produced by the extreme coloured spaces may possibly depend on the peculiar qualities of the several rays; but, perhaps, proceed from the character of the diluted or concentrated energy which they display. The violet, or blue, rays will probably hasten the process of darkening a solution of the nitrate of silver; yet have we found, that white light, attenuated to a certain degree, has likewise a power to accelerate this change. It is probable that the collected beams only retard the effect, by exciting heat, which may dispose the oxygen to adhere more strongly to its substratum. In like manner, the intense action of the red rays on the bulb of a thermometer may proceed more from their condensation than from some exclusive quality which they possess. What is the nature of that peculiar constitution which fits a ray of light to excite in the organ of

No Action whatever beyond the Limit of the Spectrum.

* It may be worth while to state here a very simple, yet decisive experiment, which we have repeated more than once. If a circle of black paper, ten inches in diameter, be pasted over the middle of a burning glass of the diameter of one foot, it will leave, around the margin of the lens, a sort of circular prism, which bends the coloured rays into a hollow double cone, whose intermediate apex occupies the focus. On directing the lens, thus partly shaded, to a bright sun, in a clear sky, a card held perpendicular to the beam, and drawn either forwards or backwards from the focus, will exhibit a narrow coloured ring, opening with intense brilliancy. Between the focus and the lens, the red rays will mark the outer edge of the vivid ring; but beyond that limit, they will cross over and tint the inside. In either case, it was easy to mark their extreme boundary. To examine the graduating calorific action of this condensed spectrum, a broad and flat piece of black sealing wax, having the gloss removed from its surface by a file, and a thin slip of white paper laid across it, was then held in the cone of light, two or three inches before the focus, and in the space of a few seconds a very narrow ring, shading inwards however, was distinctly impressed in the wax, the roughened surface being melted and left hollow and glossy, at the exact limit of the red on the outside, and smoothing slightly away on the inside. Beyond the apex of the double cone of light, a similar glazed narrow ring was imprinted, softening from the inside. In both cases, the circular impression on the wax corresponded exactly with the trace of the red rays,—an interval of the fiftieth part of an inch being easily distinguishable.

vision any peculiar sensation of colour, it seems impossible to decide. Perhaps the whole distinction consists in the difference of the celerity with which it moves. The peculiar energy of any coloured pencil of light may depend chiefly, if not entirely, on its density. From the violet to the red, the successive tints of the spectrum rise with augmented force. The blue rays appear feeble, the green cause a milder impression, the yellow and the orange begin to glow with intensity, and the red dazzles the eye. The language of painters, being grounded on nice observation, marks appositely the gradation of strength. Blue is by them termed a cold colour, green a soft colour, yellow a rich colour, and red a warm colour.

Photometer.

For measuring the intensity, or at least the calorific action of light, no instrument is so finely adapted by its peculiar delicacy as the *Photometer*, which consists of a *Differential Thermometer*, inclosed in a thin pellucid case, and having one ball made of black and the other of clear glass. It will besides admit of some variety in its form and construction, and may be rendered on the whole very commodious and portable. Yet, owing to a combination of circumstances, this elegant instrument has only been partially and reluctantly admitted; and the philosophic world has still to discharge an act of justice, by receiving it into the favour and distinction which it so well deserves. Some indeed, affecting to display superior sagacity, have taken the trouble to remark that it was only a species of thermometer, and not strictly a photometer, since it measures heat and not light. But what does the thermometer itself, except indicate *expansion*? As heat is measured by the expansion it occasions, so light is determined by the intensity of the heat which, in every supposition, invariably accompanies it. What other mode, after all, could be imagined for detecting the presence of light? How can an unknown quantity be expounded, but in terms of one already known?

Importance of that Instrument.

The photometer is adapted for a variety of important meteorological researches. If such instruments, in the hands of skilful observers, had been dispersed to the remote regions of the globe, we should ere now have obtained a body of precise facts, highly instructive in themselves, and calculated to illustrate the nature of different climates. Meanwhile, we shall endeavour to state the general consequences which may be drawn from even a scanty range of photometrical observations.

The direct and absolute action of the sun's rays on the photometer, at the elevation of 30°, may be reckoned in this climate at 120 millesimal degrees. The effect is produced by the incidence of a pencil of light, which has for its base a circle of the same diameter as the black ball, but modified and regulated in its amount by the subsequent dispersion of the accumulated heat from the whole surface of the sphere, which is four times greater than that of the generating circle. If a thin disc were, therefore, substituted instead of the ball, and presented to the perpendicular rays of the sun, the impression would be doubled or raised to 240°; or, if the emission of heat from the posterior surface of the disc were prevented, the calorific effect would amount by this accumulation to 480°, or 86 degrees on Fahrenheit's scale. Such is the rise of temperature which a dark surface of dry mould sloping at an angle of 30°, yet exactly fronting the sun, might acquire under a diaphanous shell of glass, if scarcely any portion of the heat were supposed to be conducted downwards into the mass of the earth. But since the rays of light which traverse the atmosphere under an obliquity of 30° have, in comparison with perpendicular beams, their force diminished in the ratio of 750 to 563; the action of a vertical sun, through a thin capsule of glass, might heat up a dark horizontal surface 113° by Fahrenheit's scale. On removing the glass cover, this effect, in a calm still air, would be reduced about two-thirds or to $75\frac{1}{2}$°.

The colour of the ground or substratum has very little influence in modifying the calorific action of the solar beams. The different shades of brown or gray have almost the same absorbent quality as black itself; yellow and orange begin to cause a partial reflection; but a surface even of pure chalk will not reflect perhaps the fifth part of the incident light. Hence the arid sands of Africa are often heated by a vertical sun to near the point of boiling water; in so much as to scorch the feet of the wretched traveller, and to accumulate warmth sufficient for the slow roasting of an egg. Even within the Arctic Circle, the calorific action of a bright sun, in the height of summer, may exceed 49°. In those dreary regions, accordingly, amidst a dissolving world of ice, the pitch is yet sometimes softened or melted, in the seams of the sides or the decks of ships.

Calorific Action of the Rays in different Circumstances.

It is obvious that the accumulated effect of the incident rays, must increase in proportion as the conducting power of the medium is diminished. Hence at an elevation of three miles and a half, where the density of the atmosphere is reduced to one-half, the heat communicated would, on this account alone, augment from $75\frac{1}{2}$ to 83 degrees. But the effect would be farther increased, from the smaller absorption of heat in its passage to the surface. Under the equator, the whole accumulated action would, therefore, amount to 96 degrees. All travellers, accordingly, complain of the scorching rays which the sun darts from a dark azure sky on the summits of lofty mountains. Yet the contrast is more striking in the higher latitudes. Thus, in the middle parallel of 45°, the action of the sun at the summer solstice would excite a heat of 69° at the level of the sea, and of 90° at an elevation of three miles and an half; but, at the winter solstice, it would communicate only 17° below and 46° at the altitude assumed. Saussure was accordingly very much struck with the force and brilliancy of the sun-beams on the top of Mont Blanc.

It might easily be computed that, on the supposition of a perfect calm, the surface of the earth, under the equator, will, at the medium of a year, have its temperature raised 12°; and that, in the latitude of 45°, the mean annual impression would be only 5°. But, of the whole of the light received, the colorific action on a black mould, whether emitted from the sun or shed indirectly by the sky, may be deduced from the indication of the photometer. It is only required to diminish the power of the sun's rays in the ratio of the sine of their obliquity, and to reduce

the action of the light reflected from the canopy of clouds to one-half, or what is due to the medium inclination of 30°, then to multiply the sum of these quantities by eight, and divide by three, or to take two-thirds of the quadrupled effect. Thus, suppose, while the sun's altitude is 40°, that the photometer marks 155°, which it very seldom ever reaches in this climate, and that it indicates only 20°, if merely screened from the direct action of the sun. Now, 155° multiplied by the sine of 40°, makes 87°.8, which is augmented to 97°.8 by the addition of the half of 20°, and this number again being increased in the ratio of 3 to 8, gives finally 261 millesimal degrees, or 47° on Fahrenheit's scale. When the sun is obscured in clouds, the reflected light, from a dappled sky, will sometimes in summer affect the photometer to the extent of 40°. This corresponds to a heat of 16 degrees of Fahrenheit communicated to the ground. During the fine season, the photometer seldom in cloudy weather indicates less than 15°, which is equivalent to an impression of 6 degrees on the embrowned surface of the earth. While the sun is enveloped in clouds, if the rest of the sky assumes a fine azure hue, the photometer will only mark 10°. But in the gloomy days of winter, the minute portion of light which pierces through the congregated mass of clouds will scarcely affect the photometer 5°, or excite a heat of 2° by Fahrenheit on the ground.

[E]ffect on [th]e ground [di]minished [b]y Wind:

These augments of temperature are communicated to the ground unimpaired, only in the case, however, of a perfect calm. The agitation of the atmosphere will scatter the heat before it has accumulated. When the wind creeps along the surface of the earth at the rate of eight miles in the hour, it diminishes the calorific action of the light from the sun and from the sky one-half; but if it sweeps with a velocity of 16, 24, or 32 miles in the hour, it will reduce the whole effect successively to the third, the fourth, or the fifth of its standard. The impression made on the ground seldom, therefore, exceeds the third part of the computed measure, and often will not amount to one-fifth.

The simplest and most accurate method of examining the temperature acquired during the day on the surface of the earth, is to employ a differential thermometer of the pendant kind, having about one or two feet in length, and its lower ball surmounted by a small cylindrical cavity supporting the coloured liquor. This instrument being suspended or held in a vertical position, the lower ball resting on the ground, will evidently mark, by its moveable column, the difference between temperature of the surface and that of the ambient air. In this way, we have found, during the summer months in this climate, that the ground was, by Fahrenheit's scale, generally two or three degrees warmer than the air near it in cloudy weather, and perhaps ten or fifteen degrees warmer when the sun shone powerfully upon it. But, under similar circumstances, the effect varies very considerably, according to the nature of the surface. While fresh ploughed land, for instance, indicates an increased temperature of perhaps 8°, a grass plot close beside it will scarcely show a difference of 3°. Nor is this distinction owing to any greater absorption of light by the black mould; the reflexion from the surface, in both cases, being extremely small. A thin layer of hay, whether spread on the naked soil or on the green turf, will betray the same diminished effect. The fibres of the grass exposing a multiplied surface to the contact of the air, the greater portion of the heat is hence dissipated before accumulation. A corresponding effect has been remarked with respect to the impressions of cold. Thus, in the neighbourhood of Edinburgh, after a long tract of rigorous weather, the frost was found to have penetrated 13 inches into the ground in a ploughed field, but only 8 inches in one piece of pasture ground, and 4 inches in another. But, in some of the streets of that city, the frost had descended even below two feet, so as to begin to affect the water pipes. The greater density and solidity of the pavement had no doubt conducted the frigorific impressions more copiously downwards, while the loose and spongy blades of grass had mostly scattered and wasted those impressions in the open field. This consideration, it is obvious, might lead to very important practical results.

And varies with the quality of the Surface.

The unequal action of light at the surface of the earth, whether produced by the various obliquity of the sun's rays, the different inclination of the horizon, or the alternating succession of day and night, is attempted, we have seen, by the actual flow of the heated portions of the atmosphere. Between the poles and the equator, a perpetual circulation of air is maintained, which confines the accumulating effects of heat within narrow limits. The prevalence, on the whole, of northerly winds in this hemisphere during summer, and of southerly winds in winter, tends likewise to mitigate the extreme impressions of hot and cold. But a current of warm air excited at first by the presence of the sun, continues to rise from the ground, and occasions the descent, therefore, of an opposite current of cold air, which, as the equilibrium of temperature is not soon restored, may be protracted through a great part of the night. The combined influence of these currents is hence continually exerted, in cooling down the surface of the earth; but their activity being the greatest while the solar beams fall most copiously, the accumulation of heat is checked in little more than an hour after mid-day, while its farther dissipation is prolonged through the whole of the night, sun-rise being generally the moment when the ground is coldest.

Circulation of Air between the Poles and the Equator:

Such a concatenated system of aërial currents might hence appear sufficient to explain the gradation and general balance of temperature which prevails on the surface of our globe. An horizontal stream of air must evidently cause the flow of an opposite one, since the action must be the same on every part of the same parallel of latitude. The difference of the temperature of the surface from that of the ambient air will maintain the constant play of an ascending and a descending current. In clear and calm weather, this interchange between the higher and lower strata of the atmosphere will be the most vigorous, owing then to the concentrated impression of the sun-beams. The perpetual commerce maintained in our atmosphere by the medium of these combined horizontal and vertical currents, forms no doubt an essential part of the system which attempers the constitution of this globe. But it is not the only mode by which

Regulates the Temperature of the Globe.

Climate.

nature seeks to preserve the harmony of her productions; and recent discovery has detected the existence of another auxiliary principle, extremely active, of most rapid and extensive influence, and continually at work, though subject to various modifications. To understand rightly, however, the operation of this principle, it will be necessary to recall the chief facts which have lately been disclosed relative to the PROPAGATION OF HEAT.

Propagation of Heat:

It is well known, that, though partial causes may disturb the equilibrium of temperature among bodies, there is a constant tendency to restore it again. Yet heat still remains in the state of combination, without ever assuming a distinct form. Its balance is, therefore, maintained by a very different process from that which establishes the equilibrium between the several communicating parts of a liquid. The substratum of heat is not passive, nor do the calorific particles themselves merely flow from their redundance towards another situation where they happen to be deficient. But since the presence of heat is invariably accompanied by corpuscular distention, that portion of the substance which loses it must successively contract, while the portion which gains it will in the same degree expand. The actual transfer of heat through any mass will hence give occasion to a connected series of minute internal contractions and expansions. To consider the subject more fully, we shall suppose the conducting substance to be, 1. A solid; 2. A liquid; and, 3. A gaseous fluid.

1. Through Solids:

1. When the surplus heat is conducted through a solid substance, a sort of alternating vermicular motion is excited along the whole train of communication. If heat were left to the energy of its own repulsion, it would, like light, dart with a speed almost instantaneous. But the time consumed by those interior oscillatory movements retards immensely the rate of transmission. The quickness of the oscillations themselves depends on the elasticity of the conducting substance; but their energy and extent are proportioned to the extreme difference of temperature, and the shortness of the tract, modified essentially by the peculiar nature of the conducting substance. In equal circumstances, glass transmits heat faster than wood, and metal faster than glass. But, even in the same class of conductors, the effects are very different; thus, box delivers the impressions of heat more quickly than cork, and silver conveys them with greater rapidity than platinum.

2. Through Liquids:

2. When the conducting substance is a liquid. The ordinary transmission of heat through a solid, is now greatly augmented from the diffusion occasioned by the mobility of the affected portions of the medium. Below the freezing-point, ice will conduct heat through its substance; but, after it has melted into water, a new and powerful agency is brought into play. The liquid particles, as they become successively warmer, acquire a corresponding expansion, and, therefore, rise upwards and spread through the mass, *carrying* with them and dispersing the heat which they have received. This diffusive buoyancy will depend evidently on the dilateable quality of the liquid. It is greater in alcohol than in water, and in water than in mercury; it is even more active in hot than in cold water. Near the point of congelation, indeed, the joint conducting power of water is scarcely superior to that of mere ice. The actual flow of a liquid, by whatever cause it is produced, must evidently accelerate the dissipation of heat.

3 Through Gaseous Fluids:

3. When the medium of transmission is a gaseous substance, the heat is partly still conducted through the substance of the communicating mass, as if this were solid, and partly transferred by the streaming of the corpuscles, which come to be successively affected. But a new principle seems here to combine its influence, and the rate of dispersion in aëriform media is found to depend chiefly on the nature of the mere heated surface. From a metallic surface, the heat is feebly emitted; but, from a surface of glass, or still better, from one of paper, it is discharged with profusion. If two equal hollow balls of thin bright silver, one of them entirely uncovered, and the other closely enveloped in a coat of cambric, be filled with water slightly warmed, and then suspended in a close room, the former will only lose 11 parts of heat in the same time that the latter will dissipate 20 parts. Of this expenditure, 10 parts from each of the balls is communicated in the ordinary way, by the slow recession of the proximate particles of air, as they come to be successively heated. The rest of the heat, consisting of 1 part from the naked metallic surface, and of 10 from the cased surface, is propagated through the same medium, but with a certain diffusive rapidity, which in a moment shoots its influence to a distance after a mode altogether peculiar to the gaseous fluids.

But those effects are modified by the different proximity of the air to the metallic surface. If the silver ball be covered with the thinnest film of goldbeater's skin, which exceeds not the 3000th part of an inch in thickness, the power of dispersion will be augmented from 1 to 7; if another pellicle be added, there will be a farther increase of this power, from 7 to 9; and so repeatedly growing, till after the application of five coats, when the repellent energy will reach its extreme limit or the measure of 10.

The approximation of the metallic substratum thus evidently diminishes the power of the external pellicle in darting heat. No absolute contact exists in nature; but air must approach to a boundary of pellicle, or cambric, much nearer than to a surface of metal, from which it is always divided by an interval of more than the 500th part of an inch. A vitreous surface has very nearly the same property as one of cambric or paper; from its closer proximity to the recipient medium, it imparts its heat more copiously and energetically than a surface of metal in the same condition.

Performed by Tremulous Pulses

By what process the several portions of heat thus delivered to the atmosphere, shoot through the fluid mass, it seems more difficult to conceive. They are not transported by the streaming of the heated air, for they suffer no derangement from the most violent agitation of their medium. The air must, therefore, without changing its place, disseminate the impressions it receives of heat, by a sort of undulatory commotion, or a series of alternating pulsations, like those by which it transmits the impulse of sound. The portion of air next the hot surface, suddenly acquiring heat from its vicinity, expands proportionally, and begins the chain of pulsations. In again con-

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tracting, this aërial shell surrenders its surplus heat to the one immediately before it, now in the act of expansion; and thus the tide of heat rolls onwards, and spreads itself on all sides.

But these pulsations are not propagated with equal intensity in all directions. They are most powerful in the perpendicular to the projecting surface, and diminish as they deviate from that axis in the ratio of the sine of the angle of obliquity.

Nor are the vibratory impressions strictly darted in radiating lines, but each successive pulse, as in the case of sound, presses to gain an equal diffusion. Different obstructions may hence cause the undulations of heat to deflect considerably from their course. Thus, if a cornucopia, formed of pasteboard, present its wide mouth to a fire, a strong heat will, in spite of the gradual inflection of the tube, be concentrated at its narrow end; in the same way, probably, as waves, flowing from an open bay into a narrow harbour, now contracted and bent aside, yet without being reflected, rise into furious billows.

But the same pulsatory system will enable the atmosphere to transmit likewise the impressions of cold. The shell of air adjacent to a frigid surface, becoming suddenly chilled, suffers a corresponding contraction, which must excite a concatenated train of pulsations. This contraction is followed by an immediate expansion, which withdraws a portion of heat from the next succeeding shell, itself now in the act of contracting; and the tide of apparent cold, or rather of deficient heat, shoots forwards with diffusive sweep.

That quality which enables a surface to propel the hot or cold pulses, likewise fits it under other circumstances to receive their impressions. If a vitreous or varnished surface emits heat most copiously, it will also, when opposed to the tide, arrest, with entire efficacy, the affluent wave; and if, on the other hand, a surface of metal sparingly parts with its own heat, it detains only a small share of each warm appulse, and reflects all the rest.

Pyroscope.

Hence the construction of the *Pyroscope*, a delicate and valuable instrument, adapted to measure the warm pulses of air, or the intensity of the heat that darts continually from a fire into a room, which has been vaguely and inaccurately termed *radiant heat*. It is in fact only a modification of the *differential thermometer*, one of the balls being completely gilt with a thick gold or silver leaf. The *pyroscope* being placed at some distance from the fire, the hot pulses are mostly thrown back from the bright metallic surface; but, on the naked glass ball, they produce their full impression. But the same instrument will serve equally to indicate the pulsations excited from a cold surface. Thus, in a warm apartment, the pyroscope placed before a mass of snow, a block of ice, or even a pitcher of water from the fountain, will quickly intimate the chilling impressions propagated through the ambient medium. Nor has the brightness of the fire or the glare of the snow any sensible influence to affect the result, for, of the small portion of light transmitted, what falls on the diaphanous ball passes almost without obstruction, and what strikes the gilt ball, especially if this be covered with silver leaf, is nearly all reflected.

But the pyroscope, in its simple form, is scarcely calculated for making nice observations, when exposed out of doors to the agitation of winds and the effulgence of light. A greater share of this light will generally be detained by the gilt surface than what is absorbed in its passage through the diaphanous ball. On the other hand, all the effects on the instrument will be diminished by the rapidity of the circulation of the air.

The application of the pyroscope incontestibly shows, that no pulsation, whether calorific or frigorific, ever takes place, except from a conterminous surface, which is either hotter or colder than the surrounding gaseous medium. If the general equilibrium of temperature be interrupted, such aërial pulses will arise, whether the boundary of excitation be solid or liquid. They are produced feebly from a surface of metal, though evidently stronger from mercury than from silver; but they are projected with most energy from a surface of glass, and still more powerfully from one of varnish, of paper, of ice, and of water.

Pulses of Heat or Cold excited in the Body of the Atmosphere.

But since those hot or cold pulses are darted from such various surfaces, and since the softness of the external coat, and its tendency to fluidity, seem vastly to augment their power; may they not likewise be excited from a boundary of air itself? This extension of a great principle in the economy of nature has never yet been surmised; nor can it be readily brought to the test of direct experiment. A body of air, whether hotter or colder than the general medium, it is evident, could not remain for a moment in the same detached situation, but would continue to rise or to fall. In a confined place, however, a stratum of warm air may float incumbent over a mass of colder fluid. The difference of temperature between the conterminous surfaces, would no doubt be constantly diminishing from the slow intermixture and subsequent diffusion of the adjacent portions of the air. This tendency to an equilibrium might be counteracted, by causing either a constant stream of warm air to enter by the edges of the ceiling of the apartment, or one of cold air to flow from the side of the floor. Such would be the most favourable arrangement for performing the experiment. Both the ceiling and the floor would obviously soon acquire the same temperature as the current spreading over them, and could therefore exert no influence whatever in projecting the aërial pulses. If, under such circumstances, those pulses be hence found to exist, they must necessarily proceed from the action excited at the bounding surface which divides the warm from the cold stratum of air.

Proved by Experiment.

But an arrangement, less perfect indeed, yet sufficient for ascertaining the main fact, is entirely within our reach. In a close apartment, where a good fire is constantly kept up, the ceiling and the floor may be discovered by the pendant differential thermometer to have exactly the same temperature with its adjacent stratum. Yet the upper portions of the confined air of the room will be found several degrees warmer than the lower. Instead of being divided only into opposite ranges, the whole mass, from the floor to the ceiling, will, in consequence of the expansion and buoyancy of its heated particles form a series of intermediate strata, not distinguished, however, by

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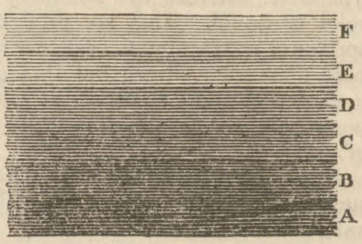
any very precise boundaries. But the intensity of action being proportional to the difference of temperature, the effect on the pyroscope must evidently be the same, whether it is produced by a single set of large pulses or by several sets of smaller ones. If, instead of one bounding surface, for example, above which the air is six degrees warmer than immediately below it, we suppose six such boundaries, each having an excess of temperature of only one degree; the pulses excited at the first of these intermediate surfaces, and successively augmented as they reach the second, third, and fourth, &c. surfaces, will at last acquire the same energy as if the aggregate difference of six degrees had been all exerted at once. Thus, the under surface of the stratum F darts pulses downwards, which, being augmented in succession at the under surfaces of the strata E, D, C, B, and A, may have finally the same intensity as if they had originated from the apposition of the extreme strata F and A. Accordingly, having planted a large screen immediately before the fire, if a delicate pyroscope be placed about the middle of the room, and a broad circular piece of metal suspended a few inches above it; on withdrawing this canopy after some time, the instrument will indicate a small impression of heat, seldom exceeding, however, one degree. But the effect may be rendered more sensible by a moderate concentration of the power excited. Suppose a hemispherical shell of thin brass, or even planished tin, having a diameter about four times greater, adapted under the naked or sentient ball of the pyroscope, which might occupy, by its surface, the place of the diffuse focus, or the middle space between the centre and the bottom of the cup. Thus mounted, the instrument will now, in the same situation, mark a very sensible calorific impression, amounting, at least in ordinary cases, to 3 or 4 degrees. Hot pulses are, therefore, actually shot downwards from all the upper strata of the confined air of a room in which a fire is kept steadily burning.



Experiment varied.

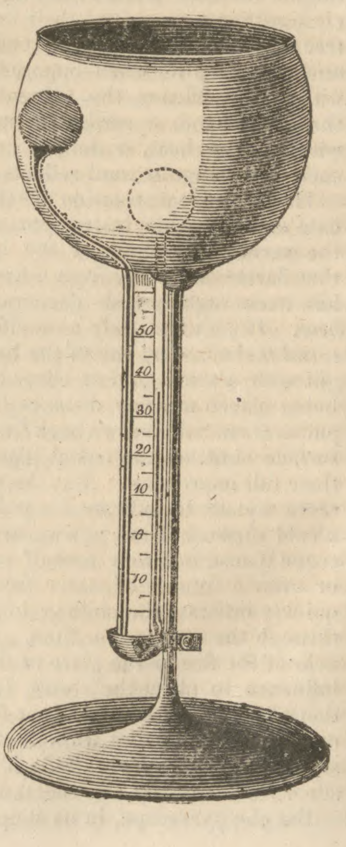
The experiment can be likewise reversed. Let an inverted pyroscope, composed of a pendant differential thermometer, have its sentient ball fitted with a small hemispherical cup which is turned downwards. This instrument being set on the floor, will remain at zero; but if lifted only a few feet, it will indicate a visible impression of cold received from below, which will increase to 3 or 4 degrees when the pyroscope is suspended near the top of the room. Wherefore, the upper surfaces of the successive decumbent strata, being comparatively colder, send upwards a series of chilling pulsations. Each of the conterminous boundaries appears thus to perform a double operation, shooting downwards impressions of heat, and darting upwards equal impressions of cold. Such a mutual exchange of influence must evidently tend to accelerate that progress to an equilibrium which the gradual intermixture of the different strata, if left quite undisturbed, would in time produce. The air of a close apartment exposed to the action of a steady fire, is hence kept agitated through its whole mass by a series of opposite tremors, which continually disperse, in all directions, the irregularities of temperature.

In open Air the Pyroscope will indicate Cold.

If the action of the pulses excited in the air of a small room be made thus apparent, how much more striking should we expect to find the effect produced by the mingled tide of commotion collected in free space from the vast body of the atmosphere itself? Taking even the lowest range of strata, to the height perhaps of two miles, including scarcely one third part of the whole aërial mass, the difference of temperature between its extreme boundary will amount to 20 centesimal degrees, or 36 on Fahrenheit's scale. The order of the series, however, is exactly the reverse of what takes place in a close room, the air of the superior regions being invariably colder than at the surface of the earth. Accordingly, the simple pyroscope, exposed in calm weather to a clear and open sky, will, at all times, if not disturbed by the influence of a strong light, indicate large impressions of cold, amounting to 5 or perhaps even 10 degrees. In most cases, it may be sufficient to screen this instrument from the direct action of the sun's rays. But the action of light will be almost neutralized, by opposing a diaphanous ball to one gilt with silver, or contrasting a ball of the different shades of green or blue, to another coated with pure gold leaf. But to procure consistent results, it is still more necessary to guard against the deranging influence of winds.

Æthrioscope described.

All these requisites are attained by adapting the pyroscope to the cavity of a polished metallic cup, of rather an oblong spheroidal shape, the axis, having a vertical position, being occupied by the sentient ball, while the section of a horizontal plane passing through the upper forms the orifice. The cup may be made of thin brass or silver, either hammered or cast, and then turned and polished on a lathe; the diameter being from two to four inches, and the eccentricity of the elliptical figure varied within certain limits according to circumstances. The most convenient proportion, however, is to have this eccentricity equal to half



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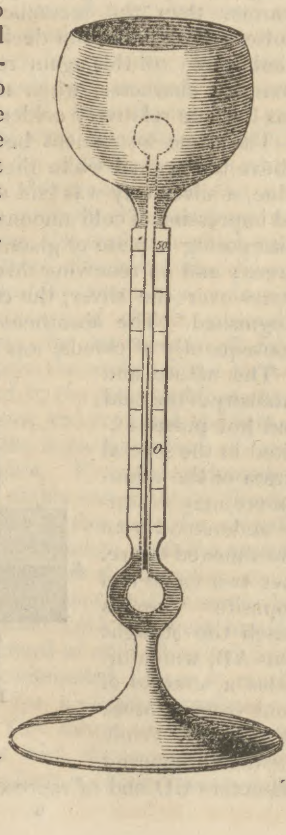
the transverse axis, and, consequently, to place the focus at the third part of the whole height of the cavity, the diameter of the sentient ball being likewise nearly the third part of that of the orifice of the cup. In order to separate more the balls of the pyroscope, the gilt one may be carried somewhat higher than the other, and lodged in the swell of the cavity, its stem being bent to the curve, and the neck partially widened, to prevent the risk of dividing the coloured liquor in carriage. A lid of the same thin unpolished metal as the cup itself is fitted to the mouth of the æthrioscope, and only removed when an observation is to be made. The scale may extend to 60 or 70 millesimal degrees above the zero, and about 15 degrees below it.

This instrument exposed to the open air in clear weather will at all times, both during the day and the night, indicate an impression of cold shot downwards from the higher regions. Yet the effect varies exceedingly. It is greatest while the sky has the pure azure hue; it diminishes fast as the atmosphere becomes loaded with spreading clouds; and it is almost extinguished when low fogs settle on the surface. The name Æthrioscope (from Αιθριος, *serenus*, *sudus*, *frigidus*) may, therefore, be justly appropriate to this new combination of the pyroscope. The sensibility of the instrument is very striking, for the liquor incessantly falls and rises in the stem with every passing cloud. But the cause of its variations does not always appear so obvious. Under a fine blue sky, the *æthrioscope* will sometimes indicate a cold of 50 millesimal degrees; yet on other days, when the air seems equally bright, the effect is hardly 30°. Particular winds at different altitudes seem to modify the result, and so perhaps may the transition from summer to winter. Four months are scarcely elapsed since this instrument was first contrived, and during that time very few opportunities have occurred for making nice observatians.



nother orm of that astrument.

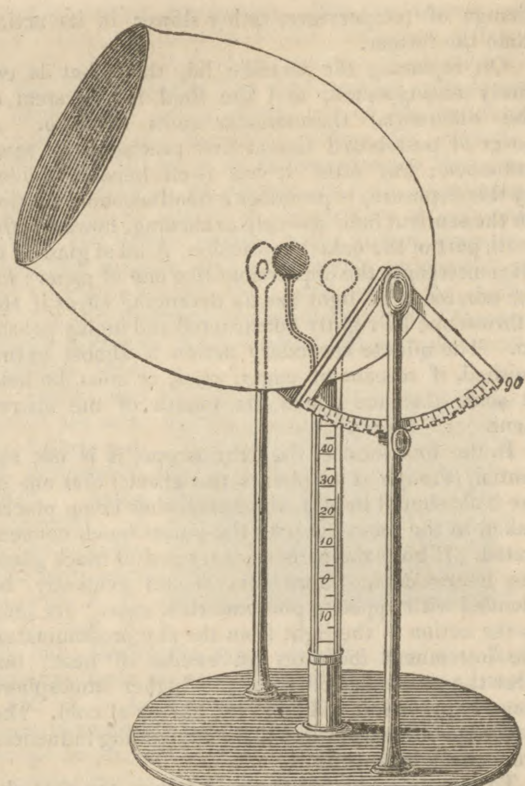
The æthrioscope might be reduced to a smaller and more compact form, by conjoining with it a pendant differential thermometer. Neither of the glass balls in this case requires to be gilt; but the lower one is encased by a hollow sphere of brass, composed of two pieces which screw together, and the upper ball occupies the focus of the cup, which needs scarcely be more than two inches wide. This variety of the instrument is equally accurate, but, under any change of temperature, rather slower in its action than the former.

On replacing the metallic lid, the effect is entirely extinguished, and the fluid in the stem of the differential thermometer sinks to zero. A cover of pasteboard has at first precisely the same influence; but after it has itself become chilled by this exposure, it produces a small secondary action on the sentient ball, scarcely exceeding, however, the tenth part of the naked impression. A lid of glass or of mica intercepts the impressions like one of paper; for the admission of light has no deranging effect if the æthrioscope be rightly constructed and highly polished. The minute secondary action is almost extinguished, if screens of paper, glass, or mica, be held at some distance above the mouth of the instrument.

In the first form of the æthrioscope, it is not essential, (though it augments the effect,) that one of the balls should be gilt, since the other being placed naked in the focus receives the pulses much concentrated. If both the balls were formed of black glass, the æthrioscopic impressions would evidently be blended with opposite photometrical ones. As long as the action of the light from the sky predominates, the instrument indicates an excess of heat; but after the pulses darted from the higher atmosphere come to prevail, it will mark the excess of cold. The liquor is stationary, when these contending influences are exactly balanced.

Secteral Æthrioscope.

To ascertain whether the cold pulses are shot obliquely as well as in the vertical direction, the æthrioscope may be constructed to turn towards any portion of the sky. To effect this, the form best adapted for the reflexion would be that of an hyperbola, whose asymptotes have an inclination equal to the visual angle of the space to be explored. But to obtain accurate results, the focal ball must be small, and the hyperbolic conoid wide and much extended. It will answer nearly the same purpose, however, to adopt a truncated spheroid, of great eccentricity: Let the height of the focus, for instance, be one inch, that of the entire cavity nine inches, and, consequently, the widest diameter six inches. The figure on the other side is rather more distended, its extreme width being equal to double the eccentricity, and the focal ball dividing the height of the orifice in the ratio of 1 to $3 + \sqrt{8}$, or 6 to 35 nearly. While that sentient ball remains always in the same position, the axis of the instrument can, by means of a screw acting on the limb of a quadrant, be depressed or elevated to any given angle. But the effect will chiefly be produced by the direct impressions: for the lateral pulses, striking less obliquely against the cavity of the spheroid, will be feebly reflected. This moveable æthrioscope was placed in a convenient situation out of doors, when the sky appeared free from clouds, and had assumed a clear blue tint. The spheroid being turned first upright, the effect was noted; but this continued still unchanged, on depressing the axis successively, till it had approached the limit of energetic range, or within 20 degrees of the horizon.



Frigorific Impressions the same in all Directions.

From every portion of the sky that subtends a given visual angle, there is hence received the same quantity of the frigorific pulses. But such would likewise be the result, if they were showered from the horizontal surfaces of the successive strata which divide the atmosphere; since although the intensity diminishes in the ratio of the sine of obliquity, a projecting space proportionally broader is for each elemental angle brought into action, as evidently appears from the annexed figure. This entire agreement between theory and observation is most satisfactory.

Influence of Clouds.

The same sectoral form of the æthrioscope discloses also the peculiar influence of clouds in obstructing the frigorific pulses excited in the atmosphere. When the sky was completely obscured by a dense canopy of clouds, the instrument being pointed to the zenith, marked only five millesimal degrees; but, on lowering it successively to the angle of 30 degrees above the horizon, it continued to indicate still the same effect. Water almost completely absorbs the pulsatory impressions of heat or cold; and may not clouds, consisting of diffuse aqueous particles, produce a similar effect? But the feeble action of five degrees, amounting scarcely to the eighth part of what is observed in clear weather, could not be any remnant of the pulses from the higher celestial regions, which had penetrated through the mass of vapours; because, if the vertical transit, through the obstructing range, allowed only an eighth part to escape, the oblique passage of 30 degrees, redoubling the extent of absorption, would have reduced the final discharge to five-eighths of a degree. The impression measured by the æthrioscope, in this case, must therefore have originated wholly in the strata of air between the under surface of the clouds and the ground. But in that narrow space, the extreme difference of temperature would be comparatively small. Hence the frigorific action is found always to diminish as the clouds descend. Nor does their variable denseness appear materially to affect the result, which is often the least, when a very thin, whitish, but low vapour, gathers in the atmosphere. Hence the æthrioscope might, with great facility, be employed to estimate the altitude of clouds.

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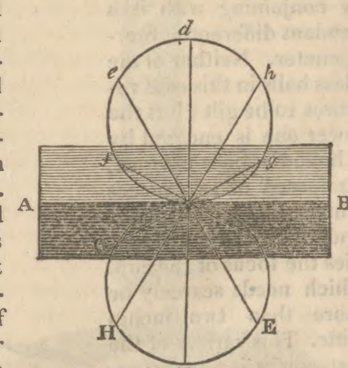
Pulses of Heat projected upwards.

As the higher strata of the atmosphere thus dart cold pulses downwards, so the lower strata must evidently project equal pulses of heat upwards. But to measure these, it would require the æthrioscope to be inverted and furnished with a pendant pyroscope. The instrument, now carried to the top of a lofty mountain, and directed to the plain below, would indicate a considerable impression of heat, nearly proportional to the quantity of ascent; and, therefore, amounting, for example on the summit of Chimboraço, to perhaps 20 millesimal degrees. But, in the same situation, the common æthrioscope might be expected to mark a impression of cold from above, as just so much diminished. No opportunity, however, has yet occurred, on a large scale, for making these interesting observations. A balloon would afford the readiest mode of verifying the theory.

The inverted æthrioscope likewise discovers the quality and measure of the pulses projected from the ground. These, in general, are very feeble, seldom in this climate exceeding 3 or 4 degrees. In the progress of a bright day, as the ground grows warmer than the incumbent air, it excites hot pulses; but, as the sun declines, the effect gradually diminishes; till this again returns, increasing with a contrary character, when the surface of the earth has become relatively colder.

The same instrument being suspended a few feet above the ground while the sky appeared clear and blue, a silver tray was laid under it, and the reflected impression of cold amounted to 25 degrees, but, on interposing a plate of glass, it was reduced to 2 degrees; and on removing this, and pouring a sheet of water over the silver, the effect was absolutely extinguished. The absorbent influence of water, and consequently of clouds, was thus distinctly shown.



The nature and intensity of the cold and hot pulses excited in the several strata of the atmosphere, may be easily understood from the annexed figure. Let two equal and opposite circles touch the straight line AB, which divides a stratum of cold from another of warm air. While the diamb opposite diameters CD and *cd* represent the force of the per-

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pendicular pulses of cold darted downwards, and of heat upwards, the chords CF, CE, CH, and CG, and C*f*, C*e*, C*h*, and C*g*, will likewise exhibit the strength of the pulses which are shot obliquely.

Importance of the Æthrioscope.

The æthrioscope thus opens new scenes to our view. It extends its sensation through indefinite space, and reveals the condition of the remotest atmosphere. Constructed with still greater delicacy, it may perhaps scent the distant winds, and detect the actual temperature of every quarter of the heavens. The impressions of cold which arrive from the north, will probably be found stronger than those received from the south. But the instrument has yet been scarcely tried. We are anxious to compare its indications for the course of a whole year, and still more solicitous to receive its reports from other climates and brighter skies.

But the facts discovered by the æthrioscope are nowise at variance with the theory already advanced on the gradation of heat from the equator to the pole, and from the level of the sea to the highest atmosphere. The internal motion of the air, by the agency of opposite currents, still tempers the disparity of the solar impressions; but this effect is likewise accelerated by the vibrations excited from the unequal distribution of heat, and darted through the atmospheric medium with the celerity of sound. Any surface which sends a hot pulse in one direction, must evidently propel a cold pulse of the same intensity in an opposite direction. The existence of such pulsations, therefore, is in perfect unison with the balanced system of aërial currents.

The most recondite principles of harmony are thus disclosed in the constitution of this nether world. But we have left no room for pursuing the details. In clear weather, the cold pulses then showered entire from the heavens will, even during the progress of the day, prevail over the influence of the reflex light, received on the ground, in places which are screened from the direct action of the sun. Hence, at all times, the coolness of a northern exposure. Hence, likewise, the freshness which tempers the night in the sultriest climates, under the expanse of an almost constant azure sky. In our northern latitudes, a canopy of clouds generally screens the ground from the impressions of cold. But, within the arctic circle, the surface of the earth is more effectually protected, by the perpetual fogs which deform those dreary regions, and yet admit the light of day, while they absorb the frigorific pulses, vibrated from the higher atmosphere. Even the ancients had remarked that our clear nights are generally likewise cold. During the absence of the sun, the celestial impressions continue to accumulate, and the ground becomes chilled to the utmost in the morning, at the very moment when that luminary again resumes his powerful sway. But neither cold nor heat has the same effect on a green sward as on a ploughed field, the action being nearly dissipated before it reaches the ground among the multiplied surfaces of the blades of grass. The lowest stratum of air, being chilled by contact with the exposed surface, deposites its moisture, which is either absorbed into the earth, or attracted to the projecting fibres of the plants, on which it settles in the form of dew or hoar frost. Hence the utility in this country of spreading awnings at night, to screen the tender blossoms and the delicate fruits, from the influence of a gelid sky; and hence, likewise, the advantage of covering walled-trees with netting, of which the meshes not only detain the frigorific pulses, but intercept the minute icicles, that, in their formation, rob the air of its cold.

The novelty and importance of the principles which regulate the distribution of heat in the atmosphere seemed to require a full discussion; but we have already outrun the space allotted for this article, and must, for the present, content ourselves with subjoining a few corollaries and general remarks. In a future part of this work we purpose to resume the consideration of the minor branches of the subject of Climate, and with more advantage, certainly, after the experiments and observations, now in progress, shall have come nearer to their conclusion. The relation of air to moisture will be treated under the word HYGROMETRY, and the complex phenomenon will receive a detailed explication under METEOROLOGY. Some farther views and illustrations may be given under PHYSICAL GEOGRAPHY, and other heads. The spontaneous arrangement and succession of the natural families of plants over the surface of the earth, in different latitudes and elevations, would alone form a very interesting article.

From what has been explained, it is easy to perceive, why the climate of an island should have a distinct character from that of a wide continent. The latter will experience a much greater range of heat and cold than the former, though the mean temperature, in like circumstances, will be the same in both. The proximity of the ocean quickly absorbs the inequality of the solar impressions. The passage from summer to winter is hence but feebly marked in detached islands. The prevalence, likewise, in such situations, of a land breeze during the day, and of a sea breeze during the night, especially near the tropics, reduces to very moderate limits the effects produced by the vicissitude of light and darkness.

The coldness of particular situations has very generally been attributed to the influence of piercing winds which blow over elevated tracts of land. This explication, however, is not well founded. It is the altitude of the place itself above the level of the sea, and not that of the general surface of the country, which will mould its temperature. A cold wind, as it descends from the high grounds into the vallies, has its capacity for heat diminished, and, consequently, becomes apparently warmer. The prevalence of northerly above southerly winds may, however, have some slight influence in depressing the temperature of any climate.

It has often been assumed as an incontrovertible fact, that the clearing of the ground, and the extension of agriculture, have a material tendency to ameliorate the character of any climate. But whether the sun's rays be spent on the foliage of the trees,

or admitted to the surface of the earth, their accumulated effects in the course of a year, on the incumbent atmosphere, must continue still the same. The direct action of the light would, no doubt, more powerfully warm the ground during the day, if this superior efficacy were not likewise nearly counterbalanced, by exposure to the closer sweep of the winds; and the influence of night must again re-establish the general equilibrium of temperature. The drainage of the surface will evidently improve the salubrity of any climate, by removing the stagnant and putrifying water; but it can have no effect whatever in rendering the air milder, since the ground will be left still sufficiently moist for maintaining a continual evaporation to the consequent dissipation of heat.

Much has been said of the comparative low temperature of the American Continent. Its majestic forests, impervious to the solar beams, and its immense lakes, diffusing their vapours, are supposed sufficient to make the climate cold and damp; and the most splendid prospects have been delineated of those changes, which an active, free, and rapidly extending population, is destined to produce in reclaiming that vast region from the rankness of nature, and opening its soil to the genial influence of heaven. Much inaccuracy and exaggeration, however, has prevailed on this subject. The extremes of summer and winter probably differ more in America than in the old world, but the mere temperature on any parallel appears, when carefully taken, to be nearly the same. Thus, Mr Warden (*Chorographical Description of the District of Columbia*, 1816) found a spring in the vicinity of the capital of the United States, and therefore a little above the level of the sea, to mark 58° in Fahrenheit's scale; but two chalybeate springs in the same quarter, though perhaps deeper seated, showed a heat of 62° and 64°. Chalybeates are not deemed warm springs, or affected by their slight mineral ingredient. But on the same parallel of 39°, the mean temperature of the ancient Continent is $63\frac{1}{2}$°.

Since the above was written, the third volume of the *Memoires de Physique et de Chimie* of the Society of Arcueil has reached us, containing, among other articles, an elaborate paper of the celebrated and accomplished traveller Baron Humboldt, *On Isothermal Lines, and the Distribution of Heat over the Globe*. Laying aside every theoretical consideration, this distinguished philosopher has here endeavoured to class the results of his own very numerous thermometrical observations with all those which he could collect from different quarters. The first difficulty that occurs is the mode of ascertaining the mean temperature of any place. It was found that half the sum of the maximum and minimum observed during the day and night, or through the summer and the winter, does not represent the true quantity. M. Humboldt has remarked that, between the parallels of 46° and 48°, the thermometer at the moment of sun-setting indicates in every season very nearly the medium temperature of the day. If this fact could be extended to other latitudes, it would greatly abridge the labour of meteorological observations.

From the data employed by M. Humboldt, he calculates that, corresponding to the latitudes of 30°, 40°, 50°, and 60°, the mean temperatures on the west side of the Old Continent are 70°.5, 63°.1, 50°.9, and 40°.6, but, on the east side of the New Continent, only 66°.9, 54°.5, 38°, and 42°.2 The isothermal lines, or lines of equal temperature, under the tropics run across the Atlantic nearly parallel to the equator; but, in the middle latitudes, they bend southerly towards the coast of America. These lines run nearly parallel into the interior of the New Continent, till they pass the Rocky Mountains, after which they bend again northwards The climate is comparatively mild on the western shore of North America.

It is well known that the difference between the temperature of the winter and of the summer months increases in advancing from the equator to the pole. On the isothermal lines of 68°, 59°, 50°, and 41°, by Fahrenheit's scale, M. Humboldt estimates the extreme range of the year at 22°, 29°, $32\frac{1}{2}$°, and 36°, on the Old Continent, and at 27°, 42°, $41\frac{1}{2}$°, and 52°, on the New Continent.—But we must now conclude, in the hope of being able to resume this interesting discussion. (D.)

CLOUD.—Although the study of the clouds constitutes a very important branch of meteorological science, yet we do find that it occupied so much of the attention of ancient naturalists, as many other much less interesting atmospheric phenomena,—a circumstance which may possibly have arisen from the very great and almost endess variety of their external forms; in consequence of which they seemed, on a superficial view, to be incapable of being so arranged and classed, as to receive specific names whereby their varieties could be commemorated. Thus, meteorologists having no means either of accurately recording their own observations, or of benefiting by those of contemporary observers, made very little progress in the knowledge of these interesting phenomena; and the various figures of clouds were regarded as being the sport of winds. or of accidental circumstances not demonstrably subject to general laws. In taking a slight survey of the observations of different writers, from the time of Aristotle to the present day, we shall see how very little progress was made in this branch of the science, till Mr Howard of London published his *Nomenclature and Observations on Clouds*. Different natural philosophers had made observations on certain properties of clouds, but no one had attempted a systematic description of them. Aristotle, in his work on *Meteorology*, seems to have been the first who attended to clouds. He remarked that they varied much in appearance; that they refracted different colours, at different times; that they possessed properties in their structure, capable, under peculiar circumstances of position with respect to the sun, of producing the phenomena of rainbows, halos, coronæ, the parhelia, &c. and he gave very minute

descriptions of these phenomena. He also notices the constant evaporation and reappearance of clouds, and gives it as his opinion, that clouds are taken into composition by the air, which, being decomposed again, the aqueous particles reassumed the forms of visible clouds. And this opinion, as we shall have occasion to notice hereafter, coincides with that of several eminent modern meteorologists.

Theophrastus, who had been the pupil of Aristotle, noticed, in a vague manner, some of the different forms of clouds, with respect, principally, to the prognostics of changes of the weather which might be deduced therefrom. He remarked, in particular, the appearance of strait horizontal sheets of clouds lodged on the summits of mountains, as an indication of wind and rain. His description of this kind of cloud corresponds so accurately with that called by the moderns *cirrostratus* or wanecloud, that it would be readily identified, even if the well known circumstance of its indicating a change to rainy weather did not render the description of this writer more clearly intelligible.

The modifications of clouds are as follows:—

Cirrus or Curlcloud. Plate LVIII. fig. 1. Def. *Nubes tenuis flexuosa et undique crescens ; altissimo aëre apparet.*

The great resemblance of some varieties of this cloud to a distended lock of hair, has suggested the name of *Cirrus*, of which *Cirrulus* and the English *Curl* are the diminutives. The curling and flexuous forms of this cloud constitute its most obvious external character.

Cumulus or Stackencloud, fig. 7. Def. *Nubes annulata densa sursum crescens.*

This cloud is well known by its flattened base and cumulated irregularly hemispherical superstructure ; hence its name *Cumulus*. The mode of its formation is by the gathering together of detached clouds into one large and elevated mass, hereafter to be spoken of. This mass, collecting all the fragments of newly formed cumuli in its vicinity, which seem as it were piled up, has received the name *Stackencloud*.

Stratus or Fallcloud, fig. 9. Def. *Nubes strata vel aquæ modo expansa terræque procumbens.*

The term *Stratus* is applied to fogs, mists, and other extensive sheets of cloud which rest on the earth's surface. There are, however, some clouds which rest on the ground in the same manner as the *stratus*, which, in other particulars, resemble the *cirrostratus*, hereafter to be described. The stratus is generally formed by the subsidence, on the approach of evening, of the vapours carried into the atmosphere by the evaporation during the day. Hence the name *Fallcloud* has been used to distinguish this modification.

The Cirrocumulus or Sondercloud, fig. 2. Def. *Nubes constans e nubeculis subrotundis et quasi in agmini appositis.*

The *Cirrocumulus* consists of a number of little orbicular masses of clouds, arranged in extensive beds, and it is to be distinguished from those features of the *Cirrostratus*, which most nearly resemble it, by the dense and compact form of its component nubeculæ. From the intermediate nature of this cloud, between the *cirrus* and *cumulus*, it has been called *Cirrocumulus*. It has received in English the name of *Sondercloud*, a word of Saxon derivation.

The Cirrostratus or Wanecloud, fig. 3, 4, 5. Def. *Nubes tenuis expansa evanescens, vel constans e nubeculis, hujus generis, in agmine appositis.*

The *Cirrostratus* is a cloud always distinguished by its flatness and great horizontal extension, in proportion to its perpendicular height. Under all its various forms, it preserves this characteristic, and is generally changing its figure, and slowly subsiding, —hence it is called the *Wanecloud.*—It often results from the fibres of the cirrus subsiding into strata of a more regularly horizontal direction ; hence it is called *Cirrostratus*.

Cumulostratus or Twaincloud, fig. 6. *Nubes densa basin planam undique supercrescens vel constans e plurimis nubibus hujusce generis communem basin habentibus.*

The *Cumulostratus* is distinguishable from the simple cumulus by the greater degree of its density, and by its having frequently several large masses of cloud rising from a common base. This base is generally of a flat form, and floats on the surface of the vapour plane, like the base of the cumulus. Hence the name cumulostratus. The base being flat like a stratus, and the superstructure resembling a large cumulus overhanging its base, in large fleecy protuberances, or rising into the forms of mountains and rocks. This modification is called *Twaincloud*, from its often resulting from the visible coalescence of two other modifications, as for example the cirrus and cumulus. When it goes on increasing in density and size, it acquires the form and character of the nimbus (described below) becoming a raincloud, pouring down rain from its lower parts. (See fig. 8.)

Nimbus or Raincloud, fig. 8. Def. *Nubis vel nubium copia pluviam effundens.*

The *Nimbus* is the ultimate resolution and fall of clouds in rain, previous to which a change of form is observed in them, sufficiently remarkable to constitute a distinct modification.

Mr Howard began his observations about fifteen years ago, and Mr Forster of London has been for several years past employed in making corresponding observations. From all these observations there has resulted, at length, a theory of the formation and changes of the clouds, which has been deduced entirely from the phenomena they have been observed to exhibit during their formation, changes, and eventual resolution into rain. As we wish, however, to avoid, as much as possible, any particular hypothesis in this article, we shall give merely an accurate account of the phenomena observed, and content ourselves with a description of the distinct modification of form

which aqueous vapour is found to assume, during the progress of the formation, changes, and resolution of clouds.

The first general observation with regard to clouds is, that they have a tendency to assume one or other of *seven* distinct modifications, and that the peculiar character of these seven modifications may be discovered in all the endless configurations exhibited by clouds under different circumstances. It may be observed, further, that the most indefinite and shapeless masses of cloud, if attentively observed, will sooner or later show a tendency to take on the form of some of the modifications; a circumstance which shows not only their distinct nature, but also proves that there are some general causes, as yet undiscovered, why aqueous vapour, suspended in the air, should assume (though with great varieties of size, extent, and figure) certain definable and constant modifications.

We shall now proceed to a more minute description of the formation and changes of the clouds, and of the prognostics of future weather to be deduced from their peculiar appearances.

Formation, Changes, and Varieties of the Cirrus.

The *Cirrus* or *Curlcloud* may be distinguished from all others by the lightness of its nature, its fibrous structure, and the great and perpetually changing variety of figures which it presents to the eye. It is generally the most elevated of clouds, occupying the higher regions of the atmosphere. As this cloud, under different circumstances, presents considerable varieties of appearance, it will be proper to consider these separately, with reference to the particular kind of weather in which they prevail.

After a continuance of clear, fine weather, we often observe a fine whitish line of cloud, at a great elevation, like a white thread stretched across the sky, the ends of which seem lost in each horizon; this is often the first indication of a change to wet weather. To this line of cirrus others are added laterally; and sometimes clouds of the same sort are propagated, as it would seem, from the sides of the line, and are sent off in an oblique or transverse direction, so that the whole phenomena has the appearance of net-work. At other times, the lines of cirrus become denser, by degrees, descend lower down in the atmosphere, and by inosculating with others from below, produce rain without exhibiting the above described appearance of transverse masses of cloud.

To the above form of the curlcloud the name of *linear cirrus* has been given, and when the reticulated intersection is added to it, the name of *reticulated cirrus*, or net-like curlcloud, has been applied to it as a mark of distinction.

The above-mentioned varieties of the cirrus are all composed of straight lines of cloud either parallel or crossing each other in different directions, but they are ranged under the head of *cirrus* or *curlcloud*, from the analogy of their texture to this cloud when it appears under curling and contorted forms, which first suggested the name. The *comoid cirrus*, vulgarly called by the country people of England the *mare's-tail cloud*, is the proper cirrus. It has somewhat the appearance of a distended lock of white hair, or of a bunch of wool pulled out into fine pointed ends, from whence it has derived its name, comoid. This form of the cirrus is most commonly an accompaniment of a variable state of the atmosphere, and often forebodes wind and rain. The direction of the fine and almost evanescent tails of this kind of cirrus, varies considerably in the course of a few hours, in very changeable weather; but when the tails have a constant direction towards the same point in the compass, for any considerable time, it has been frequently observed, that a gale has sprung up from that quarter to which they had previously pointed. In variable and warm weather in summer, when there are light breezes of wind, long and obliquely descending bands of cirrus are often observed in the air, and seem sometimes to unite distant masses of cloud together. Frequently, by means of the interposition of these cirri between a cumulus and some other cloud (as, for example, cirrostratus), the *cumulostratus* or twaincloud, and ultimately the *nimbus* or raincloud, is formed. If we attentively examine the *cirrus*, we shall find that it is in constant motion, not merely changing its form, but very often exhibiting a sort of internal commotion within the substance of the cloud, particularly in the larger end of it. Every particle seems alive and in motion, while the whole mass scarcely changes its place This motion will, on a minute examination, often appear to consist of the fibres which compose the *cirrus*, gently waving backwards and forwards, to and from each other. Often, however, it seems like minute specks all in commotion. This takes place most frequently in those large and lofty *cirri*, with rounded heads and long pointed tails, which occur in general with dry easterly wind during the summer and autumn. (See fig. 1.)

Of the Formation and Changes of the Cumulus.

The best time for viewing the progressive formation of the *Cumulus* is in fine settled weather. If we then observe the sky about the time of sunrise, or soon afterwards, we shall see small specks of cloud here and there in the atmosphere. These often appear to be the result of small gatherings, or concentrated points of the stratus or evening mist, which, rising in the morning, grows into small masses of cloud, while the circumjacent atmosphere becomes clearer.

As the sun rises, these clouds get larger,—two or three perhaps which are near each other coalesce— and at length a large cloud is formed, which, assuming a cumulated and irregularly hemispherical shape, has received the name of *cumulus* or *stackencloud*. This may properly be denominated the cloud of day, as it usually subsides in the evening, in a manner which forms the exact counterpart to its formation in the morning. It breaks up into small fragments and evaporates, and is succeeded again by the *stratus* or *fallcloud*, which has been called the cloud of night by some writers, on account of the period in which it prevails.

There are some varieties in the forms of the *Cumulus* which deserve particular notice, as they

Cloud. seem to be connected with electrical phenomena. In some kinds of fine weather, when these clouds form soon after sunrise, increase through the day, and subside in the evening, they are of a more hemispherical form, than when they occur in changeable weather. When these well-formed *cumuli* prevail during many days together, the weather is settled, and the atmospherical electrometer has been observed not to vary much in its indications. These *cumuli* are whitish-coloured, and reflect a fine strong silvery light when opposed to the sun. The *cumuli* which are seen in the intervals of showers are more variable in form, they are more fleecy, and have irregular protuberances. Sometimes they are of a blackish colour, like the clouds which the sailors call scud, and at other times they seem of a tuberculated form. *Cumuli* may, at any time, increase so as to obscure the sky, and they then generally inosculate and begin to assume that density of appearance which characterizes the twaincloud, or *cumulostratus*.

Of the Formation of the Stratus.

The *Stratus* or *Fallcloud* comprehends fogs, and all those creeping mists which in summer evenings fill the valleys, remain during the night, and disappear in the morning. The best time for observing its formation, is on a fine evening, after a hot summer's day. We shall then observe, that, as the *cumuli* which have prevailed through the day decrease, a white mist forms by degrees close to the ground, or extends only for a short distance above it. This cloud arrives at its density about midnight, or between that time and morning; and it generally disappears after sunrise. It is, for this reason, called by some writers the *cloud of night*. Under particular circumstances, it lasts longer in the morning than usual, particularly in autumn, the coming in of which season being generally marked by the greater prevalence of the fallcloud. In winter this cloud puts on a still denser appearance, and often lasts through the day, and even for many days successively; a remarkable instance of which occurred in the neighbourhood of London in January 1814. This fog spread over a large proportion of the south and west of England, and lasted about a fortnight. The stratus has often been found positively electrified, and its component particles do not wet leaves, or other substances connected with the earth. It has been supposed that the earth below it, and probably the air above it, contained a negative countercharge. The *stratus* should be distinguished from that variety of the *cirrostratus* or wanecloud, which looks much like it in external appearances, and which has usually a similar state of electricity with the earth. The criterion whereby we may judge to which of the two modifications to refer a mist is, that the *stratus* does not wet objects it alights on, but the *cirrostratus* moistens every thing.

Of the Formation and Changes of the Cirrocumulus or Sondercloud.

The *Cirrocumulus*, as has been said before, consists of a number of well-defined orbicular masses of cloud placed in close horizontal apposition, at the same time being quite asunder, or separate from each other. It is subject, however, to some varieties in the size and figure of these orbicular masses, and in their nearer or more distant approximation to each other. The most striking feature of this cloud is observable before, or about the time of thunder-storms in summer. The component *nubeculæ*, are then very dense in their structure, very round in their form, and in closer apposition than usual. See fig. 2. This kind of *Sondercloud* is so commonly a forerunner of storms, that it has been frequently spoken of by poets as a tempestuous prognostic. In rainy and variable weather, a variety of this cloud appears, strikingly contrasted with the abovementioned kind, being of a light fleecy texture, and having no very regular form in its *nubeculæ*. Under these circumstances, it is sometimes so light and flimsy in its texture, as to approach very nearly to the nature of the *cirrostratus*. Sometimes this kind of *cirrocumulus* consists of *nubeculæ* so small as scarcely to be discernible; the sky seems speckled with innumerable little round white, and almost translucid, spots. The *cirrocumulus* of fair summer weather is of a middle nature; neither being so dense as the stormy variety, nor so light as the one last described. Its *nubeculæ* vary in size, and in the degree of their proximity. In certain kinds of fine dry weather, with light gales of north and easterly wind, small detachments of cirrocumulus rapidly form and subside again, which do not lie in one plane; but, *in general*, these clouds are in horizontal arrangement. The formation of *cirrocumulus* is either spontaneous, that is, unpreceded by any other cloud; or, 2*d*, it may result from the changes of some other modification. Thus the *cirrus* or *cirrostratus* often changes into *cirrocumulus*, and *vice versa*. When this cloud prevails, we may, in general, anticipate an increase of temperature in summer; and, in winter, it often precedes the breaking up of a frost, and indicates warm and wet weather. In warm weather, in the summer time, several extensive beds of this cloud, ranged in different altitudes, and viewed by moonlight, have a very beautiful and picturesque appearance, and have been compared by poets to a flock of sheep at rest. The *cirrocumulus* either subsides slowly, as if by evaporation, or it changes into some other modification of cloud.

Of the Formation, Varieties, and Changes of the Cirrostratus or Wanecloud.

The *Cirrostratus* is characterized by shallowness or great horizontal extent, in proportion to its vertical depth; so that when the *cirrus*, or any other cloud, is observed to assume this form, we may generally expect that it will end in a *cirrostratus*. The *cirrus*, for example, after having existed some time in the higher regions of the atmosphere, often descends lower; its fibres become more regularly horizontal; and it puts on, by degrees, the character of the wanecloud. The *cirrus* more frequently changes to the *cirrostratus* than the *cirrocumulus* does, and the *cirrocumulus* more frequently than the *cumulus*.

The *cirrostratus* being once formed, sometimes re-

assumes the character of the modification from which it originated, but more frequently it evaporates by degrees, or, by inosculating with some other modification, produces the twaincloud, and eventually falls in rain.

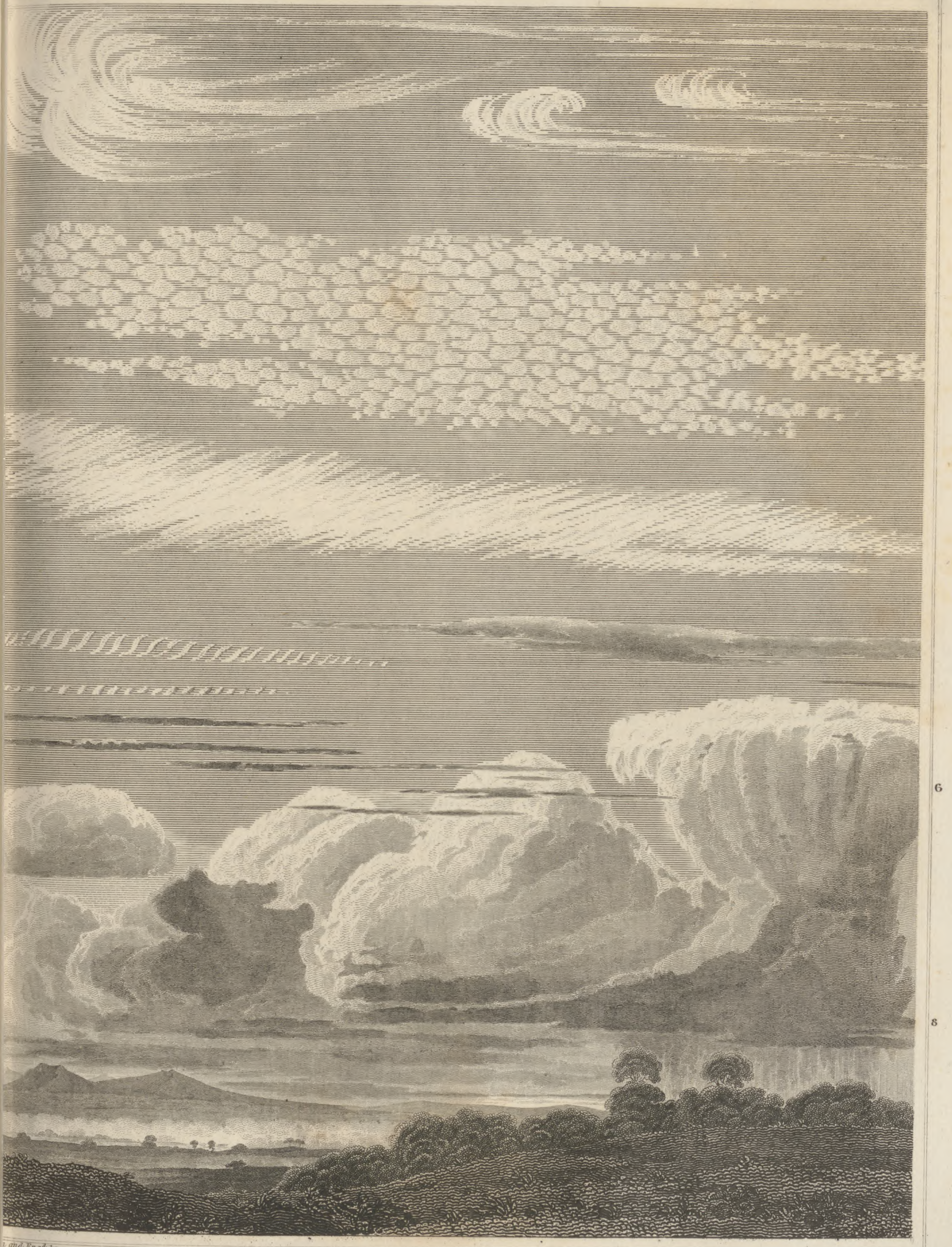
The *Cirrostratus* seldom remains long in the same form, but is observed to be constantly subsiding by degrees; hence it has been called the wanecloud from the old English verb *to wane*, to decline, or waste away. There are many varieties in the figure of the *cirrostratus*, some of which are more transitory than others. Sometimes this cloud is disposed in wavy bars or streaks, in close horizontal apposition, and these bars vary almost infinitely in size and shape. A flat and nearly horizontal cloud, composed of such streaks, is very common, particularly in variable weather, in summer. The bars, which composed this variety, are generally confused in the middle, and are most distinct towards the edges. See fig. 3. A variety not unlike this is seen in fine summer evenings, and constitutes what has been denominated the Mackerelback Sky. It is often very high in the atmosphere. We have observed, that, on ascending lofty mountains, the apparent distance of the cloud seems hardly diminished, while the *cumulus* or stackencloud has been sailing along on a level with the point of observation, or even below it. Another common variety of *cirrostratus* differs from the last in being one plane and long streak, thickest in the middle, and wasting away at its edges. This, when viewed in the horizon, has the appearance of fig. 5. It often seems to alight on the summits of the cumulostratus, as represented in the plate; and, in these cases, the density of the large twaincloud increases in proportion as these long waneclouds form and evaporate on their summit; a circumstance which looks as if the great density of the cloud depended on the inosculation and subsequent intermixture of the two different modifications with each other. The result of this intermixture, and the consequent density of the cloudy mass, is eventually the formation of the *nimbus* and the fall of rain. Another principal variety of the *cirrostratus*, is one which consists of small rows of little clouds curved in a peculiar manner. It is called the *Cymoid Cirrostratus*, and it is a sure indication of stormy weather. See fig. 4. Immediately below this, in the plate, is the representation of another less perfectly formed, having more of the character of the sondercloud. It is a variety often produced when a large cumulus passes under a long line of *cirrostratus*, like that in fig. 5., and is also a sign of variable and stormy weather. The last variety of *cirrostratus* to be mentioned, is that large and shallow veil of cloud which extensively overspreads the sky, particularly in the evening and during the night, and through which the sun and moon but faintly appear. It is in this cloud that those peculiar refractions of the sun and moon's light, called Halos, Mocksuns, &c. usually appear, and which is the surest prognostic we are acquainted with, of an impending fall of rain or snow. To these principal varieties of the *cirrostratus*, others less frequent might be added; but as their forms are almost innumerable, every meteorologist must observe them for himself. The usual termination of the *cirrostratus* is, by forming an intimate union with some other cloud, to produce rain; but, at other times, it evaporates, or changes into some other modification, as observed above.

Of the Formation of the Cumulostratus or Twaincloud.

The *Cumulostratus* might be always regarded as a stage towards the production of rain, and it frequently forms in the following manner: The *cumulus*, which in common passes along in the current of wind, seems retarded in its progress,—increases in density,—spreads out laterally,—and at length overhangs the base in dark and irregular protuberances. The change to the *cumulostratus* often takes place at once in all the cumuli which are near to each other; and their bases uniting, while the superstructures remain asunder, rising up with mountain-like or rocky summits, the whole phenomenon has a fanciful appearance. The change from *cumulus* to *cumulostratus* is often preceded by the *cirrostratus*, or some other of the lighter modifications, coming over in an upper current and alighting on the summit of the *cumulus*. Long lines of wanecloud often appear for a length of time attached transversely to the summits of the twaincloud, and give them the appearance of being transfixed by shafts. See fig. 6. *Cumuli* sometimes meet together and begin to be arranged along with joined bases, without acquiring the dense black colour of the *cumulostratus*, and, as the change is gradual, we may view the cloud in an intermediate state. *Twainclouds* vary somewhat in appearance. Those in which hard hail showers and thunder storms form, look extremely black before the change to rain, and have a most picturesque but menacing aspect, as they are seen slowly coming up with the wind. The *cumulostratus* sometimes evaporates, or changes again to *cumulus*, and sometimes it forms itself spontaneously, without the precurrence of any other cloud, and disappears again. But, in general, it ends at last in the *nimbus*, and falls in rain. Frequently, in a long range of these clouds, one part changes into *nimbus*, and rains, while the other remains a *cumulostratus*. See fig. 8. But this is not frequently the case. Having given this sketch of the modifications, it must be observed, that masses of cloud sometimes appear hardly referable to any of them; but even then, if watched long enough, they will be found to put on sufficient of the character of some of the modifications to be registered under its name.

Of the Formation and Fall of the Nimbus, or Rain-Cloud.

Hitherto we have considered only those modifications by which aqueous vapour is suspended, and kept as it were buoyant in the atmosphere. It remains now to describe a cloud which always precedes the fall of rain, snow, or hail, and which has been denominated *Nimbus*, agreeably to the notion of the ancients, who distinguish between the *imber* or a shower of rain, and the *nimbus* or cloud from which the rain came. Any of the six above described



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irr[illegible] r Curlcloud – 2. Cirrocumulus *or* Sondercloud – 3. 4. 5. Cirrostratus *or* Wanecloud – 6. Cumulostratus *or* Twaincloud – 7. Cumulus *or* Stakencloud – 8. Nimbus *or* Raincloud – 9. Stratus *or* Fallcloud.

modifications may increase so much as to obscure the sky, without ending in rain, before which the peculiar characteristic of the raincloud may always be distinguished. The best manner of getting a clear idea of the formation of the *nimbus*, is by observing a distant shower, in profile, from its first formation to its fall in rain. We may then observe the *cumulus* first arrested, as it were, in its progress, then a *cirrostratus* or *cirrus* may appear to alight on the top of it. The change to *cumulostratus* then goes on rapidly, and this cloud, increasing in density, assumes that black and threatening appearance which is a known indication of rain. Shortly afterwards the very intense blackness is changed for a more grey obscurity, and this is the criterion of the actual formation of water, which now begins to fall, while a *cirriform* crown of fibres extends from the upper parts of the clouds, and small *cumuli* enter into the under part. After the shower has spent itself, the different modifications appear again in their several stations; the *cirrus*, *cirrostratus*, or perhaps the *cirrocumulus*, appears in the higher regions of the air; while the remaining part of the broken *nimbus* assumes the form of flocky *cumulus*, and sails along in the current of wind which is next the earth. When large *cumulostrati* begin to appear again, they indicate a return of the rain; and these processes are constantly going on in showery weather, when the rapid formation and destruction of rain clouds goes on, and is attended by the other modifications in succession, in the manner above described. In continued rainy days, we cannot observe the upper parts of the *nimbus*,' which extends for miles over large tracts of country; but we have no doubt that the same processes go on slower, and on a larger scale, in continued rainy weather, which are more conspicuous in the rapid and partial formation of showers.

From these descriptions, several practical conclusions follow:

1*st*, The modifications under different circumstances of position, with respect to the sun, refract different colours, which ought to be noted down in meteorological journals, as they appear to indicate different changes of weather; and future observations may either refute or confirm those from which, at present, doubtful indications are deduced.

2*d*, The prognostics of the coming weather must always be deduced from those clouds which ultimately prevail, and in the course of a day, almost all the modifications may be seen in variable weather.

3*d*, The prevalence of the *Wanecloud* is always a sign of a fall of rain or snow.

Future observations may possibly add new subdivisions to these seven distinct genera of clouds.

(O. O.)

COACH. The history of Coaches has been given in the body of the work. The following observations on the present taste in coach-making, are communicated by an eminent Manufacturer.

During the last twenty years, the improvements on coaches, landaus, chariots, &c. have been directed to the object of accelerating their speed in travelling, by diminishing their weight, and rendering their draught more easy.

It may be doubted whether the advantages acquired in this respect are not counterbalanced by the contraction of space in the inside, and by the want of magnificence on the outside, which carriages formerly possessed; at the same time it is acknowledged in all foreign countries, that, in point of neatness, easy draught, and elegance, the coaches, &c. of Britain far surpass all others.

The only late novelty deserving notice from its ingenuity or convenience, is the improved axle, made by Callinger and others, in which, by means of a broad groove in the axle, and a corresponding one in the box or bush, fitted to each other with extraordinary accuracy, and secured at the (out-head) or outer end by a double screw, the oil is retained during a journey of 500 miles or upwards, without the trouble or necessity of stopping to grease the wheels.

At present many of our young men of fortune plume themselves no less on their knowledge of the structure than on their proficiency in the art of driving these vehicles; and the *Whip, or Four-in-hand Club*, deserves to be mentioned here, as highly characteristic of the wealth and eccentricity of the British capital.

This association, consisting of above fifty members, who are each provided with an elegant coach, and four horses of the highest breed and price, harnessed and attached to it in the most expensive manner, together with one or two spare horses, and a full retinue of servants elegantly dressed, meets at stated periods; and each member, in the exact costume of a London coachman, drives his own carriage to a short distance from town, going or returning through the Parks, or most frequented streets and squares. The enormous expence incurred by every member of this showy establishment, if it was confined to itself, would be less to be deplored than it is. But the example of so many youths of high rank and great fortune has, as might be expected, diffused itself widely; and in the two Universities of Oxford and Cambridge, among those unable to rival the Whip-Club in splendid extravagance, the spirit of coach-driving displays itself in the endless and absurd variety of two-wheeled vehicles, in the structure and denominations of which, each candidate for charioteering fame strives to surpass his rival, till invention seems nearly exhausted. We have seen a vehicle called a *suicide*, from the extreme danger of driving it; and there are some aspiring youths, who have far eclipsed all their competitors, by driving through the most crowded streets in very high carriages, drawn by two horses, the one before the other, supported on one narrow wheel!

Notwithstanding the number and variety of carriages used in Great Britain, there are not many workmen employed, properly speaking, under the name of coach-makers. We have heard, and we believe on good authority, that their number does not exceed 3000 in the whole island. The various component parts of carriages are made by workmen bearing other denominations, such as wheelers, spring-makers, platers, lace-workers, &c. whose labours the coach-maker collects and combines for his own purpose.

It is merely doing justice to this employment to

Coak ‖ Coalery.

state, that those engaged in the operative part of it have been no less remarkable for the decency and sobriety of their department, than those at the head of it have always been for great mechanical ingenuity.

COAK, or charred pitcoal, is prepared for the smelting of iron ore, by igniting the coals piled up in long ridges in the open air, and closing in the cinders with earth, when brought to a glowing red heat. For the use of the manufacturers, the method hitherto most in practice has been to burn the small or screened coal in conical ovens, built of firestone or brick; the floor is generally about six feet diameter, and the oven eight feet high, an aperture of 18 inches diameter being left at top. The small coal is thrown in to the depth of 15 inches or more, and then ignited. The oven-door is at first kept open, and the hole at top left uncovered till the mass is red-hot. The door is then closed, and, by degrees, the hole at top covered over by two large flat stones, gradually approaching each other, when the whole is left to cool. When sufficiently cooled, it is drawn out with long iron rakes, and the mass is found to have assumed a rude columnar arrangement, not much unlike starch. The oven is immediately charged again with small coal, which the heat remaining in the floor is found sufficient to ignite; and so the operation goes on. In both the above ways, good coaks are made, but the volatile products are lost. To save these, Lord Dundonald proposed to burn the coals in a close furnace, to which he adapted apparatus for conveying the coal-tar, with the ammoniacal products, into proper recipients. About the same time, Baron Von Haak, a German, constructed works in the neighbourhood of Newcastle for distilling the small coal in large cast iron cylinders, upon the plan which has since been adopted in the gas-light works; except that the soot from the furnace fires is, at Newcastle, during a certain period of the combustion, before any grey ashes have begun to arise, conveyed into a chamber contrived for the purpose, and collected for lamp-black; an economical practice, which does not appear to have been carried into the gas-works; and it is probable, that, as the practice of lighting our great towns with the carburetted hydrogen gas extends, most of the coak used in manufactures will be furnished in that way; but, as the coak thus produced will probably contain more sulphur, it is not likely that it will be fit for the smelting of iron-ore; the coak for which must, therefore, continue to be made in the old way. (P. P.)

COALERY. The article in the body of the work is perhaps one of the most useful essays that has hitherto appeared on this important subject. We shall therefore limit ourselves in this place to an account of some improvements as to the *winning* and *working* of coal, with which we have been favoured by an eminent Miner.

Of Winning.

1. What is generally called the *winning* of a coalery, is the draining of a field of coal, so as to render the several seams accessible, by pits to be sunk from the surface.

In order to determine the most eligible situation for a winning, it is requisite that the field of coal to be obtained by it, should have been previously explored by the methods described in the body of the work.

Coalery.

Supposing the field of coal (see profile A, B, Plate LIX. fig. 1.) to have been explored by the borings *a*, *b*, *c*, *d*, and the crop of the seams *e*, and that it is determined to win the tract of coal in the seams C, D, extending from the ravine at *a*, to the crop of the seams at *e*.

In this case an adit or day-level drift or *mine r f*, is set in from the ravine near to *a*, and is carried forward in a direct line until it cuts the seam C at *f*. This day-level drift also cuts the bore-hole *b* at *f*, by which the stratification from *b* to *f* is drained, and a coal-pit is then sunk upon the bore-hole *b*, *f*, from the surface to the seam C, with great facility.

In prosecuting the working of the coal from the pit *f*, towards the bore-hole C, a down-throw slip-dike *gg*, is met with, which depresses the seam C to E. The extent of this depression is ascertained by driving an horizontal stone-drift from where the seam C terminates at the dike *g g* to *h*, and by putting down the bore-hole *i*.

The day-level drift is then continued from *f* till it cuts the seam at E, and by carrying it forward to the bore-hole C, another coal-pit, *c*, *j*, is obtained in the same manner, as at *b*.

From *j* the working of the seam is carried on progressively until the upthrow slip-dike *kk* is met with. An horizontal drift is then extended from *l* to *m*, from which one boring is made upwards to the seam C, and another downwards to the seam D, by which the position of both seams is proved. The day-level drift may then be extended from the pit *c j* through the dike *k k* into the seam D to *n*, to open out the bore-hole *d*, on which another coal-pit may be sunk through the seam C to the seam D, which may also be wrought by the pit *d n*, as well as the seam C.

The workings in both seams may now be carried on from the pit *d n* till they encounter the whin dike *o o*, which must be set through by carrying a drift through it on the same line of ascent as the seam leading to it, as dikes of this description seldom alter the level of the strata which they intersect. From the whin dike the working of both seams may be carried on without further difficulty to the crop of the coal at *e*.

This tract of coal, or coalery, may now be supposed to be wrought to the utmost extent that is available, by the day-level winning, and that it is determined to win the coal lying below this level by a steam-engine.

An engine pit F, G, is, therefore, sunk upon the day-level drift *f*, and through the seam C to D, below which the pump-well or lodge H is dug. After the sinking of the engine-pit is completed, a drift is carried forward towards the rise of the seam to L, where it will cut the bore-hole *b*, *f*, and allow the coal-pit to be sunk from *f* to L, and the dike *g g* having been already explored, the water course, or engine-level drift, is carried forward from the *lodge* at H, till it cuts the lower seam D at K, and thence forward in the seam D till it cuts also the bore-hole *c j*, and the upthrow dike *k k* successively; by which

the whole extent of the seam D from G, by K to *k*, is drained and wrought by the pits *b* and *c* which have been sunk by the bore-holes discharging the water from them into the engine level.

It will be readily seen by referring to the profile, that the engine lifts the water no higher than the day-level drift *f*, by which it is discharged from the pump at *r* into the day-level drift, and thence into the ravine at *a*. The dip part of the upper seam C may also be won as far as S, by extending the engine level drift from the lodge H to S, as shown by the dotted lines.

This mode of winning coaleries can however only be pursued where the localities of the situation render it eligible; but as it frequently happens that coaleries are to be won where the surface of the ground is so nearly horizontal as not to admit of any benefit being derived from a day-level drift, it is necessary in such cases to draw the water to the surface by one or more steam-engines, as the case may require.

It frequently happens in situations of this kind, as in the neighbourhood of Newcastle-upon-Tyne, that great difficulties are encountered in the sinking through quicksands and very large feeders of water, some of which have been ascertained to communicate with the river Tyne.

The quicksands lie at various depths from the surface, as low as 30 fathoms and upwards; but the largest feeders of water are seldom met with at a greater depth than 50 fathoms. The quicksands vary much in thickness, as the feeders of water do in quantity; but a feeder which discharged nearly 4000 gallons *per* minute has been met with in one shaft. As it would be impracticable to draw such a quantity of water from the bottom of those deep mines but at an expence which could not be afforded, they are always stopped back by what is called tubbing and wedging, which is done by fixing water-tight cylinders of wood or cast iron within the circumference of the shaft, so as completely to dam back the water, and prevent its falling to the bottom of the pit. In some cases, water has been dammed back in this manner to the height of 70 fathoms, and at an expence of L.120 *per* fathom, or upwards. Quicksands are also passed through and dammed back by *tubs* or cylinders of wood or cast-iron, which are generally lowered down by ropes from the top of the pit, until they pass through the sand, and rest on the solid strata below.

As the sinking of pits under the above circumstances is attended with great expence and difficulty, no more are sunk than what may be barely necessary to work the destined part of coal below, and in some cases a whole coalery is wrought by one pit.

In situations of this kind, where the whole of the operations of the mine, as the drawing of coals and water, as well as the ventilation of the workings, are to be carried on by one pit, it follows that such pits must be made of large diameter, and divided into separate shafts.

They have therefore been sunk from 9 to 16 feet diameter, and divided into two, three, and four separate shafts by brattice, or partitions of deal boards, according to the circumstances and extent of the mine.

Plate LIX. fig. 2. represents a pit of 9 feet diameter, which is divided by the brattice or partition *a*, *b*, into a coal shaft A, and an engine shaft B.

Fig. 3. represents a pit of 12 feet diameter, divided by the partitions *a*, *b*, *c*, into two coal shafts AA, and an engine shaft B.

Fig. 4. represents a pit of 16 feet diameter, divided into three coal shafts AAA, and an engine shaft B, by the partitions *a*, *b*, *c*, *d*.

In practice it has been found that the mode of dividing the shaft, as shown by fig. 2., is the most eligible.

Coaleries have been wrought to a great extent by pits of this description; the workings have been sometimes carried to the distance of two miles from the bottom, and the height of the air course has exceeded thirty miles. Several of the pits constructed in this manner in the Newcastle district exceed 100 fathoms in depth, and some are nearly 150 fathoms deep.

Most of these large double pits have powerful steam-engines upon them, for pumping water; they are generally of Mr Watt's construction—double power—and usually exceed 100 horses' power, besides one or two more of the same construction for drawing coals, of from 20 to 30 horses' power.

As the principal feeders of water lie near the surface, the pumping engine is generally erected when the sinking commences. The pumps, which are now invariably made of cast iron, are suspended by ropes, and lowered down by capstans, as the sinking proceeds.

Rods of fir timber 6 or 7 inches square, called ground spiars, are placed (according to the size of the pumps they have to bear), one on each side of the column (set) of cast-iron pipes, to which they are firmly tied at every 9 feet by cords, called *lashings*. A five-fold block is fixed to the top of each ground-spear, the tail-ropes or *falls* of which pass round capstans placed near the top of the pit, by which the column of cast-iron pipes in the pit can be raised or lowered at pleasure. A column of pipes, generally called a "set of pumps," suspended in this way, is as steady as if it was firmly fixed in a frame of timber. Pumps of 16 to 18 inches diameter may be carried to the depth of 50 fathoms in this way, if necessary; but in this case it is expedient to add a third pair of blocks.

It is, however, only in cases of necessity that columns of pipes of this length are suspended on ground-spears, and ropes, as, if circumstances will permit, the column of pipes ought to be firmly fixed in a cistern at the depth of 25 or 30 fathoms; but in many cases no dry situation can be met with in which to place the cistern, till the pit is sunk below the level of the large top-feeders, and consequently below the tubbing, in which it has not yet been found practicable to fix a cistern.

While the pipes are suspended in the manner above described, they are called sinking sets; after they are fixed on cisterns they are called standing sets.

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Fig. 5. represents the method of suspending cast-iron pipes for sinking. *aa*, The iron blocks and ground ropes, with their falls *bb*, leading to the capstans placed in any convenient situation near the top of the pit.

dd, The iron UU's which connect the blocks with the tops of the ground-spears *ee*.

c, The hoggar-pump, generally made of fir-staves, and fixed by an iron flange and bolts to the uppermost cast-iron pipe. Always when the increased depth of the pit requires an additional pipe, the hoggar pump is taken off, and put on the top of the new pipe again.

f, The hoggar or leathern case, which delivers the water into the *laundry* box.

g, The flexibility of the hoggar enables it to accommodate itself to the gradual lowering of the pipes as the depth of the pit increases.

hh, The *bottom* rods which connect the ground-spears with the wind-bore of the pumps. The wings *ii* are cast upon the wind-bore, for the purpose of attaching the bottom rods to it by *slots* or bolts.

kkk, The lashings by which the pipes are fixed to the ground-spears.

m, The pump rod, wrought by the engine.

n, The snore-holes of the pump, which are plugged up, or kept open, as may be required by the sinkers.

Fig. 6. shows the method of fixing a standing set of pumps.

a, The bunton, made of the root end of a large oak, ten feet long and three feet square; but the larger the better. The inner end, which is the thickest, is placed in a recess cut in the stone, and the outer end is supported by an abutment of solid stone *b*, left in the pit.

The inner end of the bunton is firmly held down by wooden props, *cc*.

f, The cistern in which the pumps are placed, and into which the water from another set, either of sinking or standing pumps, may be delivered. The cistern is firmly fixed upon the bunton, and a recess is made in the side of the pit to receive it, and props *d* may be placed to fasten it down. The larger the cistern the better; there is no rule for regulating its size; but it ought, if possible, to be large enough to contain as much water as will supply its own pump, until the pump below delivers into it, when the engine begins to work.

g, The set of standing pumps placed in the cistern.

hhhh, The buntons with their cross collarings, *iiii*.

The buntings have one end fixed in the shaft wall, and the other is fastened to a *cleat*, *k*, which is nailed to the shaft brattice *ll*.

Fig. 7. shows a plan of the manner of fixing a bunton and cistern for supporting a stand-set of pumps.

aaaa Shows the recess cut in the side of the pit, with the bunton laid in its place. The inner end of the recess is cut *dove-tailed*, and the bunton wedged into it, so that it is prevented from moving forward by the shock of the pumps, when the engine is at work. The dotted lines show the situation of the cistern when placed on the bunton.

b, The pumps in the cistern.

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c c, The situation in which the succeeding sets of pumps may be placed.

d, The main or shaft brattice.

e, The bunton to which the cross collarings *ff* are nailed, for securing the pumps in their proper position.

As all the operations of the engineers should be performed in the engine shaft, without interrupting the drawing of coals in the other shafts of a double pit, as much room as possible should be preserved in the engine-shaft, by occupying as small a space in collaring the pumps as circumstances will permit.

For this purpose, iron stirrups have, for some time, been introduced in the place of cross collarings of wood, with great advantage.

If the cross collaring, *g*, fig. 7. was extended to the brattice, as shown by the dotted lines, and fixed to it by a cleat, in the same manner as the bunton *e*; by putting an iron stirrup round the pump with its ends passed through the collaring *g*, and fastened behind by the screw nuts *n*, the bunton *e*, and cross collarings *ff*, may be dispensed with, which will give much more room in the engine-shaft.

Of the different Methods of Working.

2. Thus far we have described the most improved methods of *winning* a coalery of considerable extent and depth. There are two distinct methods of working the coal, the *narrow*, and the *long* or *broad* way. The narrow way is commenced by cutting passages through the coal, both lengthways and across, leaving rectangular pillars between the passages. By the first operation one-third of the coal is generally taken out; but where the strength of the coals and the firmness of the roof will permit, a greater or less proportion of the pillars which remain are afterwards removed, commencing with the most distant, and ending with those nearest the pit. By the broad way, the coal is wrought out at once, frequently for a length of 150 yards in one face, without leaving any pillars of coal to support the roof. The former method is adapted to beds of coal which occur at a considerable depth beneath the surface, from 50 to 150 fathoms; the latter to beds which lie nearer the surface, especially if they have a tolerably strong roof.

The mode of working by the narrow way, as generally practised both in the Scotch and English coaleries, and the general principle of ventilating works so wrought, are so fully described in the body of the work, that we find little to add in this place. But as an improved system has, within the last eight years, been brought to a state of high perfection, by the ingenious Mr Buddle of Wall's End, we are happy to be permitted to avail ourselves of the description of it, as given, under his correction, by Mr Griffith, in his excellent *Report on the Leinster Coal District*. By means of Mr Buddle's plan, from seven-eighths to nine-tenths of the coal is at present raised; whilst, eight years ago, but one-half, and frequently less, was all that could be obtained; and, therefore, through his exertions, the coal owners of the north of England may be said to have increased their property at least one-third; as more coal than is equal to that proportion, is now raised out of the

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same area, than could be effected according to the old system.

Mr Buddle's ingenuity has not been confined to the improvement of the method of working coal; he has also introduced a more perfect system of ventilation; and has put in practice many simple but excellent contrivances, not only to prevent the accumulation of inflammable air in any part, but also by using hanging doors, which yield to the blast of inflammable air, and are not carried away, to prevent a general explosion throughout the mine when any cavity containing inflammable air is broken into accidentally, as the works extend; by this means, when the first blast is over, the lives of the colliers and horses in the distant parts are preserved. We shall, at present, confine ourselves to the different methods of working and supplying fresh air to the most distant parts of an extensive coalery, by one or more pits.

Plate LX. fig. 1. represents the plan of the improved system of working and ventilating coaleries in Newcastle-upon-Tyne.

The circle below the letter A is intended to represent a pit or shaft, divided from top to bottom by a boarded partition nicely joined, so as to prevent the communication of air from one side of the pit to the other. Through the right-hand division of this pit, which is called the *downcast*, the air descends. Having passed through all the excavations that have been made through the mine, which are represented by the white or uncoloured divisions, it passes up the left hand division of the pit. To aid the draught of air, a great fire is made in the furnace at B, which rarefies the air, and causes it to ascend more quickly through the upcast pit or division. The arrows point out the direction of the course of the air throughout the mine, and the red marks are walls or stoppings, built to force the passage of the air in particular directions. The dark coloured parts in the plate represent the unwrought part of the coal.

The principal advantage of the new mode of working is, that it divides the mine into any convenient number of districts, each of which is to be wrought out in its turn, and the roof suffered to close in. But to prevent the crush created by the falling in of the roof in one part, from communicating with and injuring the coal in another, a great protecting pillar or wall of coal is left between each division. By examining the figure, the several divisions or districts may be easily traced, by observing the line of large pillars.

The first operation of working the coal is represented clearly in the district E. From the bottom of the pit two parallel passages are cut, three yards broad and twelve yards asunder, at convenient distances; cross cut passages, or headings are driven to connect the parallel passages, and thereby create a complete circulation or current of air.

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The parallel passages are then continued until air again becomes deficient; a second heading is then cut, and the first is carefully closed up, so as to force the air round a lengthened circuit. This process is continued uninterruptedly round the district, as represented in fig. 1. The district being thus surrounded, broad passages, called *boards* or *rooms*, are then commenced at the lower end of the district, and are cut at regular distances upward, towards the parallel passages first described. The breadth of the boards, and that of the pillars of coal left between them, is continually varied, according to the nature of the strata which form the roof and floor of the mine. In the district F, the boards are represented in progress; this is also the case in the district K; when the boards and headings have been made throughout a whole district, this is represented by those of G and H. The next operation is to remove all the pillars; those at the farthest extremity of the district are first cut out; this operation is performed, either by commencing at one end, and proceeding regularly to the other, or by cutting the pillar in the middle, and setting a number of men to work at it. But this must depend on the strength of the roof. A few of the pillars of the district BG are represented as being removed, and the whole of the coal that could be carried away is represented as being wrought out of district I, nothing except the trifling quantity represented by the black lines being left behind. When the pillars of the district G have been wrought out nearly to the boundary pillar, between the districts I and G, the boundaries should be divided by boards and headways, and a considerable portion of them may thus be removed.

Owing to the frequent mistakes of sinking pits in improper situations, the pit A is placed in a position with respect to the coalery, that is frequently seen in practice, namely, a great part of the coal field lying to the dip, or under the natural water level of the pit. By observing the direction of the dip and rise, as represented on the plan by the great arrow, it is evident that, without some contrivance, no coal could be level or water-free below a line drawn across the pit A, at right angles to the arrow, and, consequently, half the coal of the districts F and G, and the whole of the district K, must have been left behind. To overcome this evil, the pit A is supposed to be sunk below the coal to a depth more than equal to the level of the coal at M, and a drift or passage is supposed to be horizontally cut through the strata beneath the bed of coal, till it meets the coal at M; by this means the district K may be freed from water. Had the pit been originally sunk nearer to M, all the expence and trouble of driving the stone drift would have been avoided.*

It frequently happens, that the stoppages or walls built to direct the ventilation, interrupt the communication from the various parts where the coal is

* There are, however, many reasons which may render it expedient, in particular cases, to avoid fixing the engine-pit on the lowest level of the coal-field, as when a slip or dike divides a small portion of the lower part of the field from the rest, &c. In this case, the coal wrought to the dip of the pit may easily be brought up to the drawing-pit by a high-pressure engine, fixed in some convenient station, at the head of an inclined plane.

working to the pit bottom. When this happens, a door is placed at a convenient distance on either side of the wall, which may then be removed, and the leader of the coal waggons, as he passes along, opens the first door, and, having led his waggons past, shuts it, and then opens the second door, by which means the regular ventilation of the mine is constantly preserved.

According to the plan just described, very extensive coaleries are worked from one pit; and passages or boards, amounting in the aggregate to 30 miles in length, are perfectly ventilated by a single pit.

The mode of passing the air through the different passages or boards, varies according to circumstances. When a very quick current is required, the air is passed up one board and down the next: or as represented in the plate; or up two boards and down two, or up three boards and down three. But in small coaleries, or where no inflammable air is met with, the passages of air round the boundaries of a district, as that of F, leaving all the ends of the passages or boards open for the air to circulate, is found sufficient. At the great coaleries at Newcastle, the ventilation consists of a current of air of thirty-six square feet, moving with a velocity of three feet in a second.

The different modes of removing the pillars, according to circumstances, are represented in fig. 2. Plate LX.: *aa*, *cc*, *d* and *e*, are the different modes of working pillars where it is necessary to preserve the air courses. The pillars are wrought in the manner represented at *bb*, where the outer parts are much damaged and cracked by the pressure of the roof and floor. And *ff*, when the roof is not sufficiently strong to remain up, while the whole pillar is removing. In this case the centre part is left, and both ends are carried away.

The consequence of working the boards too wide is represented in the elevation, fig. 3. The pillars on either side of the board, *g*, are represented as much broken both at top and bottom by the pressure of the roof and floor, and the coal is rendered useless. Besides, the passage through the board is nearly closed by the approach of the roof and floor towards each other. The board *h'* represents the appearance in elevation, of one that is driven of a proper width. In this case, the coal on both sides is solid, and the roof and floor remain in their original positions. In working all coaleries, it is better to drive the boards too narrow than too broad; in the first case, when the pillars are to be removed, the roof and the coal are both sound, and the whole of it may with safety be removed; but, in the latter, the centre of the pillars only, as represented by *bb* in the plate, can be removed. As there is no account in the original article of the *broad method* of working; we shall, therefore, lay before our readers Mr Griffith's account of this method. A good account may also be found in Mr Farey's *Survey of Derbyshire*.

Many of the shallow and thin beds of coal in Yorkshire are worked in the broad way, but the breadth of the banks vary in almost every coalery, from certain local circumstances. We shall describe one, the principles of which may be applied to any shallow coalery, and the proper breadth of the banks, which depend on the nature of the roof, will be determined better by practice than precept.

Fig. 4. represents a very simple and excellent method of working in the *broad way*. A shaft is divided into two parts, in the manner already described; *bbb* are double drifts, with proper headings for air; *cc* and *d* are banks, each thirty yards broad; the dotted marks represent three rows of wooden pillars which support the roof. The light shade represents the parts already worked out where the roof has fallen.

The first operation in the work is to drive the several double drifts. Those on each side of the pit must be completed to the full extent, before any other workings can go on. The three double drifts at right angles to the first may then be commenced; and, having advanced 20 or 30 yards, the great working or bank may be commenced, by breaking down the coal along the lines *ee* upwards. The coals are drawn from the face of the banks on both sides, through the openings or headings by which the air is introduced, as represented by the arrows. I and *f* are double doors to prevent the air from the left bank returning directly to the pit; by this means, it is forced along the face of the workings in the right bank. The first banks being proceeded on to a certain distance, a third and fourth may be commenced to the right and left, and others may be wrought to the rise, by connecting the rise drifts by cross ones at right angles to them, and working upwards from the cross drifts in the manner that has been described.

According to this plan, a very extensive coalery may be worked from one pit; but horses should be used to draw the coal under ground; and, if the coal be thin, part of either the floor or roof must be removed, to give sufficient headway. The most approved method of conveying the coals from the face of the work to the pit bottom is the following: First, a light cast iron railway must be laid from the pit bottom, through all the main passages of the coalery, and, branching from these, small moveable railways should be laid, from the nearest point of the main passage, or mother gate, as it is usually called, to the face of the workings. When the collier has broken down the coals, another man, known by the names of putter, hurrier, &c. is employed to fill the coal into a wicker basket, or wooden box, placed on a wooden carriage with iron wheels; this is pushed to the mother gate, along the railway, and the putter returns with an empty box, which has been placed in the mother gate; a waggon-boy arrives from the pit, leading a horse which draws six carriages chained together, each having an empty box on it. These boxes are lifted off; and, by means of a small *crane*, the full boxes are successively raised, and placed on the carriages, which, when thus laden, are drawn by the horse along the railway to the pit bottom, from whence the boxes are drawn up to the surface, and the empty ones returned.

The reader will find much useful information on the ventilation of mines in Mr Buddle's valuable tract, entitled, *The first Report of the Sunderland Society for preventing Accidents in Coal Mines.*

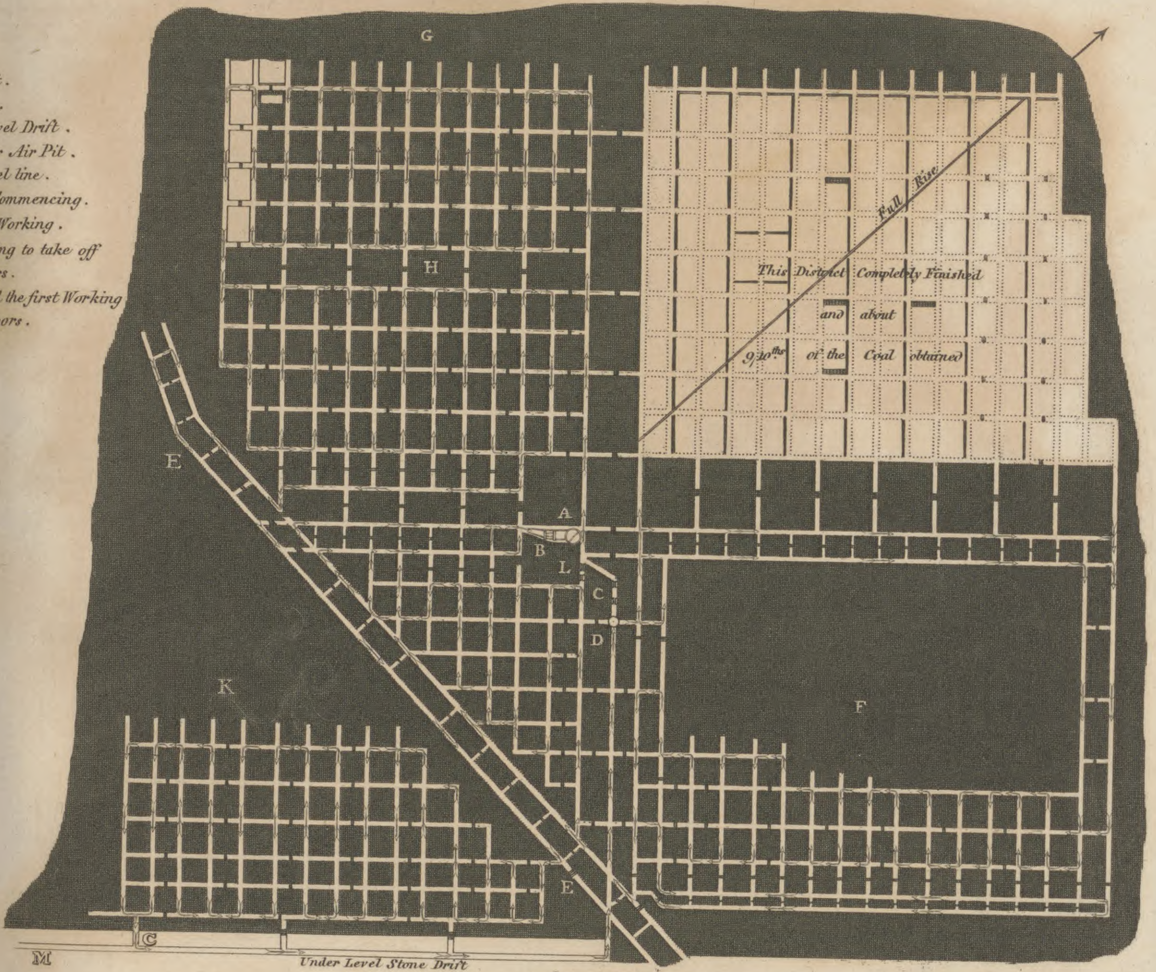
(P. P.)

COALERY.

PLATE LX.

A [1]. Pit.
B F[1]ace.
C U[1]r level Drift.
D S[1]le or Air Pit.
E W[1] level line.
F D[1]ct, Commencing.
[1]irst Working.
G D[1]inning to take off
[1]Pillars.
H D[1]ished the first Working
L D[1]e Doors.

Fig. 1.
IMPROVED MODE of WORKING COAL MINES.



Scale 66 Yards to an Inch

Fig. 2.
MODE of Reducing the PILLARS, and Retaining the VENTILATION.

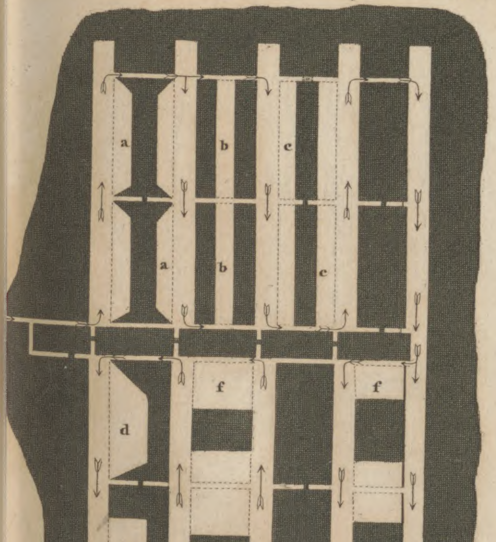


Fig. 3.
Elevation of the Effect of Driving Broad & Narrow Boards

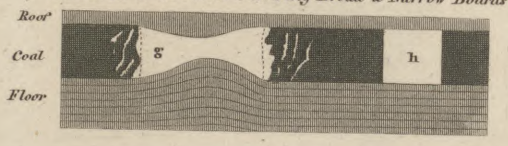
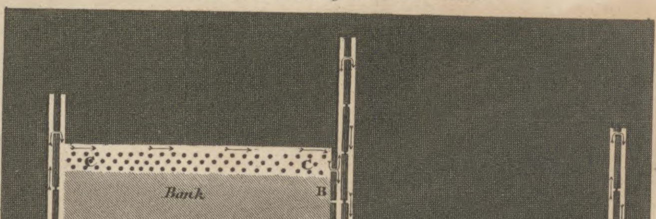


Fig. 4.
BROAD METHOD of WORKING COAL.



Eng.d by W. Archibald Edin.r

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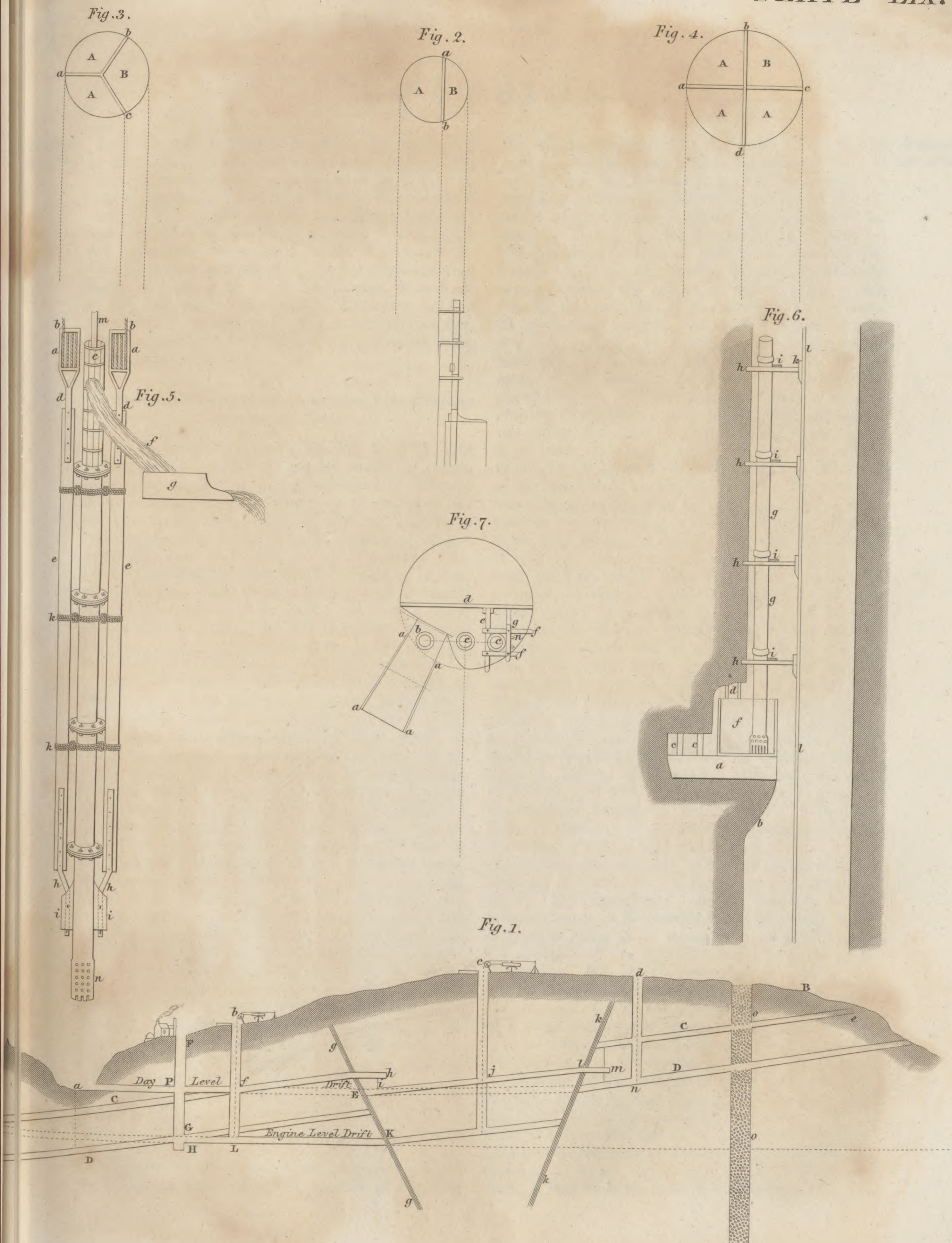

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COHESION.

The corpuscular forces, on which the mechanical properties of the aggregates of matter depend, have been in some measure considered, as far as they relate to solids, in the articles Bridge and Carpentry of this *Supplement* (P. 497, 622): there are however other modifications of these forces, which are principally exemplified in the Cohesion of Fluids; and which afford us a series of phenomena, highly interesting to the mathematician, on account of the difficulty of investigating their laws, and of considerable importance to the natural philosopher, from the variety of forms in which they present themselves to his observation.

Section I.—*Fundamental Properties of the Cohesion of a Single Fluid.*

The three states of elastic fluidity, liquidity, and solidity, in all of which the greater number of simple bodies are capable of being exhibited at different temperatures, are not uncommonly conceived to depend on the different actions of heat only, giving a repulsive force to the particles of gases, and simply detaching those of liquids, from that cohesion with the neighbouring particles, which is supposed to constitute solidity. But these ideas, however universal, may be easily shown to be totally erroneous: and it will readily be found, that the immediate effect of heat alone is by no means adequate to the explanation of either of the changes of form in question.

There can never be rest without an equilibrium of force: and if two particles of matter attract each other, and yet remain without motion, it must be because there exists also a repulsive force, equal, at the given distance, to the attractive force. If we imagined the atoms of matter to be impenetrable spheres, only resisting when their surfaces came into actual contact, it would follow, that the degree of repulsive force exerted at the same distance must be capable of infinite variation, so as to counterbalance every possible modification of the attractive force, that could operate between the particles. In this there would be no mathematical absurdity, and it may sometimes even be convenient to admit the hypothesis as an approximation: but we know from physical considerations that the actual fact is otherwise. The particles of matter are by no means incompressible: the repulsion varies indeed very rapidly when they approach near to each other; but the distance of the particles, and the density of the substance must inevitably vary, in some finite degree, from the effect of every force, that tends to produce either compression or expansion.

In elastic fluids, the law of the repulsive force of the particles is perfectly ascertained; and it has been shown to vary very accurately in the inverse ratio of their mutual distances. It is natural to inquire whether this repulsive force, continued according to the same law, would be capable of affording the resistance exhibited by the same bodies in a liquid or solid form, and holding the cohesive force in equilibrium: but in order to answer this question, it would be necessary to determine the law of the variation of the cohesive force with the variation of the density. Now if this force extended to all particles within a given distance of each other, whatever the density might be, the number of particles similarly situated within the sphere of action being as the density, and each one of this number being attracted by an equal number, the whole cohesion urging any two particles to approach each other would obviously, as Laplace has observed, be as the square of the density: but since this cohesive force would increase, with the increase of density accompanying compression, more rapidly than any repulsive force like that of elastic fluids, there could never be an equilibrium between forces thus constituted: for, as Newton has justly remarked, the force of repulsion must be supposed to affect the particles immediately contiguous to each other only, their number not increasing with the density. Nor is there any reason to infer, from the phenomena of cohesion, that this force extends to a given minute distance, rather than to a given number of particles, as that of repulsion appears to do. It would indeed be possible to assign a law for the variation of cohesion, which would reduce the repulsion of liquids and of elastic fluids to the action of the same force, without any other modification than that which depends on the mutual distance of the particles; but this law is in itself so improbable, that it cannot be considered as affording an admissible explanation of the phenomena; for it would be required that the force of cohesion should diminish, instead of increasing, with every increase of density, and with a rapidity 19 times as great as the repulsion increased. For the height of the modulus of elasticity of all kinds of gaseous substances remaining unaltered by pressure, that of steam would still be only one twentieth as high as the modulus of elasticity of water, even if the steam were compressed by 1200 atmospheres; and the resistance to any minute change of dimensions would be twenty times as great in water as in steam of equal density, and the variation of the repulsion would be in the same proportion. It is therefore simplest to suppose the repulsion itself to be also twenty times as great, and the cohesion little or not at all altered by the effect of a slight compression or extension: and we shall have no difficulty in imagining this abrupt change in the magnitude of the repulsive force to depend on an increase of the number of particles to which it extends; supposing that when cohesion begins to affect them, this number becomes four or five times as great as before, and that it is not further increased by a greater increase of density; although, like the distance to which the force of cohesion itself extends, it may be liable to some modification from the

effects of a change of temperature. Thus it is probable that the number of particles co-operating, both in repulsion and in cohesion, is diminished by the effect of heat; for the diminution of the elasticity of a spring is much more than proportional to the expansion of its substance, although the primitive repulsive force of the single particles may very possibly be as much augmented by an elevation of temperature in this case as in that of an elastic fluid: the cohesive powers of liquids are also diminished by heat, and indeed in a considerably greater degree than the stiffness of springs, although there can be no doubt that there is a considerable analogy in these changes. However this may be, it appears that the force of cohesion cannot be supposed to vary much with the density, and it is therefore allowable to consider it as constant, at all distances, as far as its action extends; while that of repulsion, though it may operate in some degree at distances somewhat greater, may still be considered, on account of its greater intensity at smaller distances, as equivalent to a resistance terminating at a more minute interval than that to which the action of cohesion extends.

The distance at which cohesion commences between the particles of gaseous fluids appears to depend entirely on the temperature, and for any one fluid it is generally reduced to one half by an elevation of about 100° of Fahrenheit. In whatever way the particles are caused to approach nearer than this distance to each other, they become subject to the action of this force, and rush together with violence, and with a great extrication of heat, until the increased repulsion affords a sufficient resistance to the cohesion, and the gas is converted into a liquid. Superficial observers have sometimes imagined, that liquids possessed little or no cohesion; and it has generally been supposed that their cohesive powers are far inferior to those of solids. But that all liquids are more or less cohesive, is sufficiently shown by their remaining attached, in small portions, to every substance capable of coming into intimate contact with them, in opposition to the effect of gravitation, or of any other force: and the cohesion of mercury is still more fully exemplified by the well-known experiment of a column, standing at a height much exceeding that of the barometer, when it has been brought, by strong agitation or otherwise, into perfect contact with the summit of the tube, and is then raised into a vertical position; the summit of the tube supporting, or rather suspending the upper parts, and each stratum the stratum immediately below it, with a force determined by the excess of its height above that of the column equivalent to the atmospherical pressure. The perfect equality of the cohesion of a given substance in the states of solidity and liquidity, appears, however, only to have been asserted in very modern times: and the assertion has only been confirmed by a single observation of the sound produced by a piece of ice, compared with the elasticity exhibited in Canton's experiments on the compressibility of water; the results demonstrating that the resistance is either accurately or very nearly equal in both cases.

The real criterion of solidity is the lateral adhesion, which prevents that change of internal arrangement, by which a fluid can alter its external dimensions without any sensible difference in the mutual distances of its particles taken collectively, and consequently without any sensible resistance from the force of cohesion. It is probable that this lateral adhesion depends upon some symmetrical arrangement of the constituent parts of the substance, while fluidity requites a total independence of these particles, and an irregularity of situation, affording a facility of sliding over each other with little or no friction. The symmetry of arrangement, when continued uniformly to a sensible extent, is readily discoverable by the appearance of crystallization; but there are several reasons for supposing it to exist, though with perpetual interruptions, in more uniform masses, or in amorphous solids. It is obvious that the lateral adhesion, confining the particles so as to prevent their sliding away, performs an office like that of the tube of a barometer to which the mercury adheres, or like that of the vessels employed by Canton and Zimmerman for confining water which is compresssd; and enables the cohesive and repulsive powers of the substances to be exhibited in their full extent. Nor can we obtain any direct estimate of these powers from the slight cohesion exhibited, in some circumstances, by liquids in contact with the surface of a solid which is gradually raised, and carries with it a certain portion of the liquid; an experiment which had been often made, with a view of determining the mutual attractions of solids and fluids, but which was first correctly explained, as Laplace observes, by our countryman Dr Thomas Young, from its analogy with the phenomena of capillary tubes.

There are however still some difficulties in deducing these phenomena from the elementary actions of the forces concerned, whatever suppositions we may make respecting their primitive nature. The intermediate general principle of a hydrostatic force or pressure, proportional to the curvature of the surface, had been employed long ago by Segner, and had been considered by him as the result of corpuscular powers extending to an insensible distance only. But Segner's reasoning on this point is by no means conclusive, and he has very unaccountably committed a great error, in neglecting the consideration of the effects of a double curvature. There is also an oversight in some of the steps of the demonstration attempted by Dr Young in his *Lectures*, which has been pointed out by an anonymous writer in Nicholson's *Journal:* and Mr Laplace's final equation for determining the angle of contact of a solid and a liquid, which Dr Young had first shown to be constant, has been considered as completely inaccurate, and as involving an impossibility so manifest, as to destroy all confidence in the theory from which it was deduced. A demonstration, which appears to be less exceptionable, was lately published in the *Philosophical Magazine;* and it may serve, with some farther illustrations, for the present purpose.

It is only necessary to consider the actions of such of the particles of the liquid, as are situated at a distance from the surface shorter than that, to which the cohesive force extends; for all those, which are more internal, must be urged equally in all di-

rections by the actions of the surrounding particles. Now it will readily be perceived, that the first or outermost stratum of particles will cohere very weakly with the stratum below it, having only its own attraction to bind it down; that the second will be urged by a force nearly twice as great; and that the cohesion will gradually augment, by increments continually diminishing, until we arrive at the depth of the whole interval to which the force extends: and below this it will remain constant, the number of particles within the given distance not undergoing any farther change. It has been observed by Mr Laplace, that this partial diminution of the density of the surface is likely to be concerned in facilitating the process of evaporation; and it has been cursorily suggested in another quarter, that the polarisation of light by oblique reflection may be in some measure influenced by this gradation of density. But its more immediate effect must be to produce that uniform tension of the surface, which constitutes so important a principle in the phenomena of capillary action; for since the cohesion in the direction of the surface is the undiminished result of the attractions of the whole number of particles constituting the stratum, acting as they would do in any other part of the substance, it follows that a small cubical portion of the liquid, situated in any part of the space which we are considering, will be pressed laterally by the whole force of cohesion, but above and below by that part only, which is derived from the action of the strata above it; so that this minute portion must necessarily tend to extend itself upwards and downwards, and to thicken the superficial film; and at the same time to become thinner in the direction of the surface, and to shorten it in all its dimensions; unless this alteration be prevented by some equivalent tension acting in a contrary direction: and this tension must be always the same in the same liquid, whatever its form may be, the thickness of the whole stratum being always extremely minute in comparison with any sensible radius of curvature.

Upon these grounds we may proceed to determine the actual magnitude of the contractile force derived from a given cohesion extending to a given distance. Supposing the corpuscular attraction equable throughout the whole sphere of its action, the aggregate cohesion of the successive parts of the stratum will be represented by the ordinates of a parabolic curve: for at any distance x from the surface, the whole interval being a, the fluxion of the force will be as $\mathrm{d}x\ (a-x)$, since a number of particles proportional to $\mathrm{d}x$ will be drawn downwards by a number proportional to a, and upwards by a number proportional to x, and the whole cohesion, at the given point, will be expressed by $ax-\frac{1}{2}x^2$: and this at last becomes $\frac{1}{2}a^2$, which must be equal to the undiminished cohesion in the direction of the surface: consequently the difference of the forces acting on the sides of the elementary cube will everywhere be as $\frac{1}{2}a^2-ax+\frac{1}{2}x^2$, and the fluxion of the whole contractile force will be $\mathrm{d}x\ (\frac{1}{2}a^2-ax+\frac{1}{2}a^2)$, the fluent of which, when $x=a$, becomes $\frac{1}{6}a^3$, which is one-third of $a\times\frac{1}{2}a^2$, the whole undiminished cohesion of the stratum.

We may therefore conclude in general, that *the contractile force is one-third of the whole cohesive force of a stratum of particles, equal in thickness to the interval, to which the primitive equable cohesion extends*; and if the cohesive force be not equable, we may take the interval which represents its *mean* extent, as affording a result almost equally accurate. In the case of water, the tension of each inch of the surface is somewhat less than three grains: consequently we may consider the whole cohesive and repulsive force of the superficial stratum as equal to about nine grains. Now since there is reason to suppose the corpuscular forces of a section of a square inch of water to be equivalent to the weight of a column about 750,000 feet high, at least if we allow the cohesion to be independent of the density, their magnitude will be expressed by $252.5\times750{,}000\times12$ grains, which is to 9 as $252.5\times1000{,}000$ to 1; consequently the extent of the cohesive force must be limited to about the 250 millionth of an inch: nor is it very probable that any error in the suppositions adopted can possibly have so far invalidated this result, as to have made it very many times greater or less than the truth.

Within similar limits of uncertainty, we may obtain something like a conjectural estimate of the mutual distance of the particles of vapours, and even of the actual magnitude of the elementary atoms of liquids, as supposed to be nearly in contact with each other: for if the distance, at which the force of cohesion begins, is constant at the same temperature, and if the particles of steam are condensed when they approach within this distance, it follows that at 60° of Fahrenheit the distance of the particles of pure aqueous vapour is about the 250 millionth of an inch: and since the density of this vapour is about one-sixty thousandth of that of water, the distance of the particles must be about forty times as great: consequently the mutual distance of the particles of water must be about the ten thousandth millionth of an inch. It is true that the result of this calculation will differ considerably according to the temperature of the substances compared; for the phenomena of capillary action, which depend on the superficial tension, vary much less with the temperature than the density of vapour at the point of precipitation: thus an elevation of temperature, amounting to a degree of Fahrenheit, lessens the force of elasticity about one ten-thousandth, the superficial tension about one thousandth, and the distance of the particles at the point of deposition about a hundredth. This discordance does not, however, wholly invalidate the general tenor of the conclusion; nor will the diversity resulting from it be greater than that of the actual measurements of many minute objects, as reported by different observers; for example those of the red particles of blood, the diameter of which may be considered as about two million times as great as that of the elementary particles of water, so that each would contain eight or ten trillions of particles of water, at the utmost. If we supposed the excess of the repulsive force of liquids above that of elastic fluids to depend rather on a variation of the law of the force than of the number of particles cooperating with each other, the extent of the force of cohesion would only be reduced to about two-thirds; and on the whole it appears tolerably safe to conclude, that, whatever errors may have affected the determi-

Cohesion.

nation, the diameter or distance of the particles of water is between the two thousand and the ten thousand millionth of an inch.

SECTION II.—*Relations of Heterogeneous Substances.*

We must now return from this conjectural digression to the regions of strict mathematical argument, and inquire into the effect of the contact of substances of different kinds on the tension of their common surfaces, and on the conditions required for their equilibrium. Whatever doubts there may be respecting the variation of the number of particles cooperating when the actual density of the substance is changed, there can be none respecting the consequence of the contact of two similar substances of different densities; for the less dense must necessarily neutralise the effects of an equivalent portion of the particles of the more dense, so as to prevent their being concerned in producing any contractility in the common surface: and the remainder, acting at the same interval as when the substance remained single, must obviously produce an effect proportional to the square of the number of particles concerned; that is, of the difference of the densities of the substances. This effect may be experimentally illustrated by introducing a minute quantity of oil on the surface of the water contained in a capillary tube; the joint elevation, instead of being increased, as it ought to be according to Mr Laplace, is very conspicuously diminished: and it is obvious that since the capillary powers are represented by the squares of the density of oil and of its difference from that of water, their sum must be less than the capillary power of water, which is proportional to the square of the sum of the separate quantities.

Upon these principles, we may determine the conditions of equilibrium of several different substances meeting in the same point, neglecting for a moment the consideration of solidity or fluidity, as well as that of gravitation, in estimating the contractile powers of the surfaces and their angular situations. We suppose then three liquids, of which the densities are A, B, and C, to meet in a line situated in the plane termination of the first: the contractile forces of the surfaces will then be expressed by $(A-B)^2$, $(A-C)^2$, and $(B-C)^2$: and if these liquids be so arranged as to hold each other in equilibrium, whether with or without the assistance of any external force, the equilibrium will not be destroyed by the congelation of the first of the liquids, so that it may constitute a solid. Now, unless the joint surface of the second and third coincides in direction with that of the first, it cannot be held in equilibrium by the contractility of this surface alone; but supposing these two forces to be so combined, as to produce a result perpendicular to the surface of the first substance, this force may be resisted by its direct attraction; the forces which tend to cause the oblique surface to move either way on it, balancing each other, and the perpendicular attraction being counteracted by some external force holding the solid in its situation. Consequently the force expressed by $(B-C)^2$, reduced in the proportion of the radius to the cosine of the angle, must become equal to the difference of the forces $(A-B)^2$ and $(A-C)^2$, and if the radius be called unity, this cosine must be $\frac{(A-C)^2-(A-B)^2}{(B-C)^2}=$ $\frac{2AB-2AC-(B^2-C^2)}{(B-C)^2}=\frac{2A-(B+C)}{B-C}$, which is the excess of twice the density of the solid above the sum of the densities of the liquids, divided by the difference of these densities: and when there is only one liquid, and $C=0$, this cosine becomes $\frac{2A}{B}-1$, vanishing when $2A=B$, and the density of the solid is half of that of the liquid, the angle then becoming a right one, as Clairaut long ago inferred from other considerations. Supposing the attractive density of the solid to be very small, the cosine will approach to -1, and the angle of the liquid to two right angles: and on the other hand, when A becomes equal to B, the cosine will be 1, and the angle will be evanescent, the surface of the liquid coinciding in direction with that of the solid. If the density A be still further increased, the angle cannot undergo any further alteration, and the excess of force will only tend to spread the liquid more rapidly on the solid, so that a thin film would always be found on its surface, unless it were removed by evaporation, or unless its formation were prevented by some unknown circumstance which seems to lessen the intimate nature of the contact of liquids with dry solids. For the case of glass and mercury, we find $\frac{A}{B}$ about $\frac{1}{8}$, and the cosine $-\frac{3}{4}$, which corresponds to an angle of 139^0: and if we add a second liquid, the expression will become $\frac{-6-C}{8-C}$, which will always indicate an angle less than 180^0, as long as C remains less than 1, or as long as the liquid added is less dense than glass. There must, therefore, have been a slight inaccuracy in the observation mentioned by Mr Laplace, that the surface of mercury contained in a glass tube becomes hemispherical under water: and if we could obtain an exact measurement of the angle assumed by the mercury under these circumstances, we should at once be able to infer from it the comparative attractive density of water and glass, which has not yet been ascertained; although it might be deduced with equal ease from the comparative height of a portion of mercury, contained in two unequal branches of the same tube, observed in the air and under water. The cosine is more exactly $-.735$, in the case of the contact of glass and mercury, and $\frac{2A}{B}=.265$, whence $\frac{A}{B}=\frac{1}{7.55}$, which is a disproportion somewhat greater than that of the specific gravities; but it must probably vary with the various kinds of glass employed.

There is also another mode of determining the angle of contact of a solid with a single liquid, which has been ingeniously suggested by Mr Laplace; it is derived from the principle of the invari-

ability of the curvature of the surface at a given elevation; and its results agree with those which we have already obtained, except that it does not appear to be applicable to the case of more than one liquid in contact with the given solid. Supposing a capillary tube to be partially inserted into a liquid, if we imagine it to be continued into a similar tube of the liquid, leaving a cylinder or column of indefinite length in the common cavity; then the action of either tube, upon the liquid immediately within it, will have no tendency either to elevate or to depress the column: but the attraction of the portion of the tube above the column will tend to raise it with a certain force, and the lower end of the tube will exert an equal force upon the portion of the column immediately below it; and this double force will only be opposed by the single attraction of the liquid continuation of the tube, drawing down the column above it, so that the weight of the column suspended will be as the excess of twice the attractive force of the solid above that of the liquid. Now supposing two plates of the solid in question to approach very near each other, so that the elevation may be very great in comparison with the radius of curvature of the surface, which in this case may be considered as uniform; the weight suspended will then be simply as the elevation, which will be the measure of the efficient attractive force, and will vary with it, if we suppose the nature of the solid to vary, the radius of curvature varying in the inverse ratio of the elevation: but the radius of curvature is to half the distance of the plates, as unity to the numerical sine of half the angular extent of the surface, or the cosine of the angle of the liquid, so that this cosine will be inversely as the radius, or directly as the elevation; that is, as the efficient attractive force, which is expressed by $2A - B$, becoming $= -1$ when A vanishes, and consequently being always equal to $\frac{2A - B}{B}$, as we have already found from other considerations. If we wished to extend this mode of reasoning to the effect of a repulsive force counteracting the cohesion, we should only have to suppose the diameter of the tube diminished on each side by the interval which is the limit of the repulsion, since beyond this the repulsion could not interfere with the truth of the conclusions, for want of any particles situated in the given directions near enough to each other to exhibit it: and within the stratum more immediately in contact with the solid, the forces may be supposed to balance each other by continuing their action along its surface until they are opposed by similar forces on the outside of the tube or elsewhere: and indeed such a repulsive stratum seems in many cases to be required for affording a support to the extended surface of the liquid when the solid does not project beyond it. It may also be shown, in a manner nearly similar, by supposing the column to be divided into concentric cylinders, that the superficial curvature of the liquid will not affect the truth of the conclusion.

Section III.—*Forms of Surfaces of Simple Curvature.*

We may now proceed upon the principle, admitted by all parties, of a hydrostatic pressure proportional to the curvature of the surface of the liquid, which is equivalent to a uniform tension of that surface, and which either supports the weight or pressure of the fluid within its concavity, or suspends an equal column from its convexity, whether with the assistance of the pressure of the atmosphere, or more simply, by the immediate effect of the same cohesion, that is capable of retaining the mercury of the barometer in contact with the summit of the tube: and on this foundation, we may investigate the properties of the forms assumed by the surface; first considering the cases of simple curvature, which are analogous to some of the varieties of the elastic curve, and next those of the surfaces having an axis of revolution, which will necessarily involve us in still more complicated calculations.

A. *Let the height of the curve at its origin be a, the horizontal absciss x, the vertical ordinate y, the sine of the angular elevation of the surface s, the versed sine v, and the rectangle contained by the ordinate and the radius of simple curvature r; then the area of the curve will be rs, and $y = \surd(a^2 + 2rv)$.*

The fluxion of the curve z is jointly as the radius of curvature $\frac{r}{y}$, and as the fluxion of the angle of elevation, which we may call w, or $dz = \frac{r}{y}\,dw$, and $dx = \surd(1 - s^2)\,dz = \surd(1 - s^2)\frac{r}{y}dw$; but $\surd(1-s^2)\,dw = ds$, consequently $dx = \frac{r}{y}\,ds$, and $y\,dx$, the fluxion of the area, becomes equal to $r\,ds$, and the area itself to rs. In order to find y, we have $dy = s\,dz = s\frac{r}{y}\,dw = \frac{r}{y}\,dv$; whence $y\,dy = r\,dv$, and $y^2 = 2rv + aa$, y becoming equal to a when v vanishes.

It may also be immediately inferred, that the area of the curve must vary as the sine of the inclination of the surface, from considering that, according to the principles of the resolution of forces, the tension being uniform, the weight which it supports must be proportional to that sine.

Scholium. The value of r for water at common temperatures, is about one hundredth of a square inch, according to the results of a variety of experiments compared by Dr Young; or more correctly, if we adopt the more recent measurement of Mr Gay-Lussac, .0115: for alcohol Mr Gay-Lussac's experiments give $r = .0047$; and for mercury $r =$ .0051. Dr Young had employed .005 for mercury, a number which appears to be so near the truth, that it may still be retained for the greater convenience of calculation. Hence in a very wide vessel, the smallest ordinate a being supposed evanescent, and $y = \surd(2rv) = .1516\,\surd v$, the height of the water rising against the side of the vessel, when $v = 1$, will be .1516; and the utmost height at which the water will adhere to a horizontal surface, raised above its general level, will be $2\surd r = .2145$. For mercury, y becomes, in these circumstances, $\surd(.0102v) =$

Cohesion. $.101 \sqrt{v}$, and if $s = .735$, $v = .322$, and the depression of the surface in contact with a vertical surface of glass becomes .0573; and again when $v = 1.735$, as in the case of a large portion of mercury lying on a plate of glass, the height y is .133: and if the glass had no attraction at all for mercury, v would become 2, and the height .1428. The actual tension of the surface of mercury is to that of water as $.0051 \times 13.6$ or .06936 to .0115; that is a little more than six times as great; while the angle of contact of mercury with glass, which is more attractive than water, would have led us to expect a disproportion somewhat greater. If we take a mean of these results, and estimate it at seven times, the value of $\sqrt{r}$ will be reduced, by immersing mercury standing on glass into water, in the ratio of $\frac{6}{7} \times \sqrt{\frac{13.6}{12.6}}$, since the buoyant effect of the water increases the value of r, so that $\sqrt{(2r)}$ will be .09; and the angle approaching to 180°, the height will be about .127.

B. *When the curve is infinite the absciss x becomes* $= \frac{1}{2} \sqrt{r}\,\text{HL} \frac{2\sqrt{r} - \sqrt{(4r - yy)}}{2\sqrt{r} + \sqrt{(4r - yy)}} + \sqrt{(4r - y^2)}$, *reckoning from the greatest ordinate $y = 2\sqrt{r}$; and the excess of the length of the curve above the absciss is* $2\sqrt{r} - \sqrt{(4r - y^2)}$.

In this case, a being $= 0$, $y^2 = 2rv$: but $\frac{dx}{dy} = \frac{1 - v}{s} = \frac{1 - v}{\sqrt{(2v - vv)}} = \frac{2r - 2rv}{\sqrt{(4r - 2rv)}\sqrt{(2rv)}} = \frac{2r - yy}{\sqrt{(4r - yy)}y}$; and, by the common rules for finding fluents, $x = \frac{2r}{4\sqrt{r}}\,\text{HL} \frac{2\sqrt{r} - \sqrt{(4r - yy)}}{2\sqrt{r} + \sqrt{(4r - yy)}} + \sqrt{(4r - y^2)}$; which vanishes when $y = 2\sqrt{r}$: and for the length of the curve, since $\frac{dz}{dy} = \frac{1}{s} = \frac{1}{\sqrt{(2v - vv)}} = \frac{2r}{\sqrt{(4r - yy)}\,y}$, subtracting the former fluxional coefficient from this, we have $\frac{y\,dy}{\sqrt{(4r - yy)}}$ for the fluxion of the difference; and the fluent of this is $-\sqrt{(4r - y^2)}$.

Corollary 1. Hence, where the curve is vertical, we find $x = .5328 \sqrt{r}$: and where the inclination amounts to a second, $x = 11.28 \sqrt{r}$; for example, in the case of water, $\sqrt{r}$ being .1072, the latter value of x will become 1.21, and the former .056: so that the surface must be considered as sensibly inclined to the horizon at the distance of more than an inch from the vessel, but scarcely at an inch and a half: and for mercury, these distances will be two-thirds as great. This circumstance must not be forgotten when mercury is employed for an artificial horizon; although, where the vessel is circular, the surface becomes horizontal at its centre; and in other parts the inclination is materially affected by the double curvature. Cohesion.

Corollary 2. The form of the surface coincides in this case with that of an elastic bar, or a slender spring, of infinite length, supposed to be bent by a weight fixed to its extremity; since the curvature of such a spring must always be proportional to its distance from the vertical line passing through the weight. We may therefore deduce from this proposition the correction required for the length of a pendulum like Mr Whitehurst's, consisting of a heavy ball, suspended by a very fine wire. Now the radius of curvature of the spring is $\frac{Maa}{12fy}$ (Art. BRIDGE, Prop. G); the modulus of elasticity, of which M is the weight, being for iron or steel about 10,000,000 feet in height; and since 80 inches of the wire weighed 3 grains, the thickness a, supposing it to have been $\frac{1}{5}$ or $\frac{2}{5}$ of the breadth, as is usual in wire flattened for hair springs, must have been about $\frac{1}{375}$ of an inch: the weight f was 12251 grains: and the weight M of ten million feet must have been $\frac{3}{80} \times 12 \times 10000000$ grains; consequently $\frac{Maa}{12fy} = \frac{3 \times 10000000}{80 \times 12251 \times 375 \times 375y} = \frac{1000}{12251 \times 375y} = \frac{1}{4594y}$, which is analogous to $\frac{r}{y}$ in these propositions; consequently $\sqrt{r} = \frac{1}{68}$; and the whole value of $\sqrt{(4r - y^2)}$ from $y = 2\sqrt{r}$ to $y = 0$, is $\frac{1}{34}$ of an inch. Now supposing the spring to have been firmly fixed at the axis of vibration, the excess of its length above the ordinate will always be measured by $2\sqrt{r} - \sqrt{(4r - y^2)}$; but $\sqrt{(4r - y^2)} = \sqrt{(4r - 2rv)} = \sqrt{r}\sqrt{(4 - 2v)}$, which is the chord of the supplement of the arc of vibration in the circle of which the radius is $\sqrt{r} = \frac{1}{68}$; and the ball will be drawn above its path to a height equal to the distance between this circle and another of twice the diameter, touching it at its lowest point: but a perpendicular falling from this point on the wire would always be found in a circle twice as much curved as the first circle, and if it were made the centre of vibration, the ball would always be raised twice as far above its original path as the distance between the first circle and the second, which is the measure of the effect of the curvature; so that the pendulum must be supposed to be shortened half as much as this; that is, in the present instance, $\frac{1}{136}$ of an inch. If however the spring remained in Mr Whitehurst's experiments, at liberty to turn within the clip, and was firmly fixed at a considerable distance above, the variation of the length must have been only that which belongs to half of the arc of vibration; that is, one fourth as great as in the former case, since the versed sine is initially as the square of the arc; but since it would affect the spring both above and below the clip, it would be doubled from this cause, and would amount to $\frac{1}{272}$ of an inch: so that the true correction would be liable to vary from .00735 to .00367, according

Cohesion. to the mode of fixing the wire. But since this error must have affected both Mr Whitehurst's pendulums in an equal degree, and the result was deduced from the difference, and not the proportion of the lengths, it is free from any inaccuracy on this account. The calculation however sufficiently proves the necessity of attending to the effect of different modes of fixing the spring, in order that no variation may be made in the different experiments compared without a proper correction. The elasticity of such a wire, as Mr Whitehurst employed, could not have produced any sensible error, by co-operating with the force of gravitation, since it did not amount to one two-millionth part of the weight of the ball.

C. *The relation of the ordinate and absciss may be generally expressed by means of an infinite series.*

When the curve is concave towards the absciss throughout its extent, the ordinate may be compared with the lengths of hyperbolic and elliptic arcs, as Maclaurin has shown with respect to the elastic curve (*Fluxions*, § 928): but his solution fails in the more ordinary cases of the problem; and even where it is applicable, the calculation is very little facilitated by it. Segner has made use of two different forms of infinite series, each having its peculiar advantages with respect to convergence in particular cases, and other forms may be found, which will sometimes be more convenient than either of these. The value of the cotangent $\frac{dx}{dy}$ being in general

$$\frac{1-v}{\surd(2v-vv)} = \frac{2r-2rv}{\surd(4r-2rv)\surd(2rv)} = \frac{2r-yy+aa}{\surd(4r-yy+aa)}\cdot\frac{1}{\surd(yy-aa)},$$

we may retain either of these fractions, and expand the other by means of the binomial theorem.

1. In the first place, making $4r+a^2=c^2$, we have $(c^2-y^2)^{-\frac{1}{2}} = \frac{1}{c}+\frac{1}{2}\cdot\frac{y^2}{c^3}+\frac{3}{4.2}\cdot\frac{y^4}{c^5}+\frac{5}{8.2.3}\cdot\frac{y^6}{c^7}+\ldots$, and $\frac{dx}{dy} = \frac{2r+aa}{\surd(yy-aa)}\left(\frac{1}{c}+\frac{1}{2}\cdot\frac{y^2}{c^3}+\frac{3}{4.2}\cdot\frac{y^4}{c^5}+\ldots\right) - \frac{1}{\surd(yy-aa)}\cdot\left(\frac{y^2}{c}+\frac{1}{2}\cdot\frac{y^4}{c^3}+\frac{3}{4.2}\cdot\frac{y^6}{c^5}+\ldots\right)$. Now, in order to find the fluents of the separate terms, we have first $\int\frac{dy}{\surd(yy-aa)} = \text{HL}\,(y+\surd[yy-aa])$; and calling this logarithm L,

$$\int y^2\frac{dy}{\surd(yy-aa)} = \frac{y}{2}\surd(y^2-a^2)+\frac{a^2}{2}\text{L};$$

$$\int y^4\frac{dy}{\surd(yy-aa)} = \left(\frac{y^3}{4}-\frac{3a^2y}{8}\right)\surd(y^2-a^2)+\frac{3a^4}{8}\text{L};$$

$$\int y^6\frac{dy}{\surd(yy-aa)} = \left(\frac{y^5}{6}-\frac{5a^2y^3}{24}+\frac{5a^4y}{16}\right)\surd(y^2-a^2)+\frac{5a^6}{16}\text{L};\text{ and}$$

$$\int y^8\frac{dy}{\surd(yy-aa)} = \left(\frac{y^7}{8}-\frac{7a^2y^5}{8.6}+\frac{7.5a^4y^3}{8.6.4}-\frac{7.5.3a^6y}{8.6.4.2}\right)\surd(y^2-a^2)+\frac{7.5.3a^8}{8.6.4.2}\text{L}:$$

whence by substitution we have $x = \frac{2r+aa}{4r+aa}\text{L} + \left(\frac{2r+aa}{2(4r+aa)^3}+\frac{1}{4r+aa}\right)\cdot\left(\frac{y}{2}\surd[y^2-a^2]+\frac{a^2}{2}\text{L}\right)+\ldots$.

2. If we reduce $\frac{1}{\surd(yy-aa)}$ into a series, we have $\left(1-\frac{aa}{yy}\right)^{-\frac{1}{2}} = 1+\frac{1}{2}\frac{a^2}{y^2}+\frac{3}{4.2}\cdot\frac{a^4}{y^4}+\frac{5}{8.2.3}\cdot\frac{a^6}{y^6}+\ldots$, and $\frac{dx}{dy} = \frac{2r+aa-yy}{\surd(cc-yy)}\cdot\left(\frac{1}{y}+\frac{1}{2}\cdot\frac{a^2}{y^3}+\frac{3}{4.2}\cdot\frac{a^4}{y^5}+\ldots\right)$. Then, for the fluents,

$$\int\frac{ydy}{\surd(cc-yy)} = \surd(c^2-y^2);\ \int\frac{dy}{y\surd(cc-yy)} = \text{HL}\,\frac{c-\surd(cc-yy)}{c+\surd(cc-yy)} = \text{L};$$

$$\int\frac{dy}{y^3\surd(cc-yy)} = -\frac{\surd(cc-yy)}{2c\,cyy}-\frac{1}{2cc}\text{L};$$

$$\int\frac{dy}{y^5\surd(cc-yy)} = \left(-\frac{1}{4c^2y^4}+\frac{3}{8c^4y^2}\right)\surd(c^2-y^2)+\frac{3}{8c^4}\text{L};$$

$$\int\frac{dy}{y^7\surd(cc-yy)} = \left(-\frac{1}{6c^2y^6}+\frac{5}{24c^4y^4}-\frac{5}{16c^6y^2}\right)\surd(c^2-y^2)-\frac{5}{16c^6}\text{L};$$

and by combining these fluents we obtain a second series for x.

3. These series may be employed with advantage where the initial ordinate is very small, the one being more convenient for the upper, and the other for the lower part of the curve: but where the elevation a is more considerable, the form of the curve will be more readily determined by means of fluents derived from circular arcs. Beginning with the expressions $\frac{dx}{dy} = \frac{1-v}{\surd(2v-vv)}$, and $y^2 = a^2+2rv$, we may seek for a value of x in terms of v; and since $2ydy = 2rdv$, $dy = \frac{r}{y}dv = \frac{rdv}{\surd(aa+2rv)}$, and $dx = \frac{1-v}{\surd(2v-vv)}\cdot\frac{rdv}{\surd(aa+2rv)}$. The binomial $(aa+2rv)^{-\frac{1}{2}}$ may then be expanded into a series of integral powers of v, and the fluents may be found by means of the equations $\int\frac{dv}{\surd(2v-vv)} = \int\frac{dv}{s} = w$, the arc

of which v is the versed sine; $\int \frac{v\mathrm{d}v}{s} = s - w$; $\int \frac{v^2\mathrm{d}v}{s} = \left(\frac{v}{2} - \frac{3}{4} \cdot 2\right) s + \frac{3}{8} \cdot 4\, w$; $\int \frac{v^3\mathrm{d}v}{s} = \left(\frac{v^2}{3} - \frac{5}{24} \cdot 4v + \frac{5}{16} \cdot 8\right) s - \frac{5}{16} \cdot 8\, w$; and $\int \frac{v^4\mathrm{d}v}{s} = \left(\frac{v^3}{4} - \frac{7}{8.6} \cdot 4v^2 + \frac{7.5}{8.6.4} \cdot 8v - \frac{7.5.3}{8.6.4.2} \cdot 16\right) s + \frac{7.5.3}{8.6.4.2} \cdot 16\, w$.

4. Another series may be obtained by the expansion of $\frac{1}{\sqrt{(2v - vv)}}$ into $\frac{1}{\sqrt{(2v)}} \cdot \left(1 + \frac{1}{4} v + \frac{3}{8.2} v^2 + \frac{5}{16.2.3} v^3 + \ldots\right)$, whence

$$\frac{\mathrm{d}x}{\mathrm{d}y} = \left(1 - \frac{yy - aa}{2r}\right) \sqrt{\frac{r}{yy - aa}}$$

$\left(1 + \frac{1}{4} \frac{yy - aa}{2r} + \frac{3}{8.2}\left(\frac{yy - aa}{2r}\right)^2 + \ldots\right)$: the fluxions belonging to the series $(y^2 - a^2) - \frac{1}{2}\mathrm{d}y$, $(y^2 - a^2)^{\frac{1}{2}}\,\mathrm{d}y$, $(y^2 - a^2)^{\frac{3}{2}}\,\mathrm{d}y$; and the fluents of these are HL $(y + \sqrt{[y^2 - a^2]}) = \mathrm{L}$; $\frac{1}{2} y \sqrt{(y^2 - a^2)} - \frac{1}{2} a^2\,\mathrm{L}$; $(\frac{1}{4}\sqrt{(y^2 - a^2)} + \frac{3}{8} a^2)\, y \sqrt{(y^2 - a^2)} + \frac{3a^4}{8}\,\mathrm{L}$; which afford a result somewhat resembling that which is deduced from the first method.

5. We may also express x in a series of integral powers of y only, if we suppose it to begin at some point in which the curve is inclined to the horizon, where the height is p, calling it at other points $p + y$; and making $\frac{\mathrm{d}x}{\mathrm{d}y} = \tau = a + by + cy^2 + \ldots$; we have then $x = \beta + ay + \frac{1}{2}by^2 + \frac{1}{3}cy^3 + \ldots$, and the area $\int (p + y)\,\mathrm{d}x = \gamma + pay + \frac{1}{2}pby^2 + \ldots + \frac{1}{2}ay^2 + \frac{1}{2.3}by^3 + \frac{1}{3.4}cy^4 + \ldots$, which must be equal to rs (Prop. A.): but $s = \frac{\mathrm{d}y}{\sqrt{(\mathrm{d}x^2 + \mathrm{d}y^2)}} = \frac{1}{\sqrt{(1 + \tau\tau)}}$, which may be developed by means of the Taylorian theorem $\varphi(\mathrm{A} + \mathrm{H}) = \varphi\mathrm{A} + \frac{\mathrm{d}(\varphi\mathrm{A})}{\mathrm{dA}}\,\mathrm{H} + \frac{\mathrm{d}^2(\varphi\mathrm{A})}{\mathrm{dA}^2} \cdot \frac{\mathrm{H}^2}{2} + \ldots$, taking $\mathrm{A} = a$, and $\mathrm{H} = by + cy^2 + \ldots$, whence

$\mathrm{H}^2 = b^2y^2 + 2bcy^3 + (2bd + c^2)y^4 + \ldots$

$\mathrm{H}^3 = b^3y^3 + 3b^2cy^4 + \ldots$; consequently $rs = r\varphi a \ldots$

$$= \frac{r}{\sqrt{(1 + aa)}} + \frac{r}{\mathrm{d}a} \cdot \mathrm{d}\frac{1}{\sqrt{(1 + aa)}}\,(by + cy^2 + dy^3 + ey^4 + \ldots)$$
$$+ \frac{r}{2\mathrm{d}a^2} \cdot \mathrm{d}^2 \frac{1}{\sqrt{(1 + aa)}} \cdot (b^2y^2) + 2bcy^3 + (2bd + c^2)y^4 + \ldots)$$
$$+ \frac{r}{2.3\mathrm{d}a^3} \cdot \mathrm{d}^3 \frac{1}{\sqrt{(1 + aa)}}\,(b^3y^3 + 3b^2cy^4 + \ldots) =$$
$$\gamma + pay + (\tfrac{1}{2}pb + \tfrac{1}{2}a)y^2 + (\tfrac{1}{3}pc + \tfrac{1}{6}b)y^3 + \ldots;$$

and hence by comparing the homologous terms, we find $\gamma = \frac{r}{\sqrt{(1 + aa)}}$, $\frac{r}{\mathrm{d}a} \cdot \mathrm{d}\frac{1}{\sqrt{(1 + aa)}} \cdot b = pa = \frac{-ra}{(1 + aa)^{\frac{3}{2}}} \cdot b$, and $b = -\frac{p}{r}(1 + aa)^{\frac{3}{2}}$; and in a similar manner we may determine the subsequent coefficients; but the calculation is somewhat laborious, and has no particular advantages.

6. We may still more readily obtain a similar series for y in terms of the powers of x with constant coefficients; calling $\frac{\mathrm{d}y}{\mathrm{d}x}$, t, and making $t = bx + cx^3 + dx^5 + \ldots$ whence $y = a + \frac{1}{2}bx^2 + \frac{1}{4}cx^4 + \frac{1}{6}dx^6 + \ldots$, and the area $\int y\,\mathrm{d}x = ax + \frac{1}{2.3}bx^3 + \frac{1}{4.5}cx^5 + \ldots = rs = \frac{rt}{\sqrt{(1 + tt)}} = rt\,(1 - \frac{1}{2}t^2 + \frac{3}{4.2}t^4 - \frac{3.5}{8.2.3}t^6 + \ldots)$. But $t^3 = b^3x^3 + 3b^2cx^5 + \ldots$ and $t^5 = b^5x^5 + \ldots$: hence we have the equation

$$\frac{ax}{r} + \frac{1}{2.3r}bx^3 + \frac{1}{4.5r}cx^5 + \ldots =$$
$$\begin{array}{lll} bx + cx^3 & + dx^5 & + \ldots \\ -\frac{1}{2}b^3x^3 & -\frac{1}{2} \cdot 3b^2cx^5 & - \ldots \\ & +\frac{3}{8}b^5x^5 & + \ldots \end{array}$$

consequently $b = \frac{a}{r}$, $c = \frac{1}{2.3r}b + \frac{1}{2}b^3$, and $\mathrm{d} = \frac{1}{4.5r}c + \frac{3}{2}b^2c - \frac{3}{8}b^5$.

It is the less necessary to enter into any further detail of these results, as we have a table, calculated by Segner, with his son's assistance, which is sufficient to afford us a general idea of the forms of the curve in different circumstances. The unit of this table is the quantity $\sqrt{r}$, which Segner calls the modulus of capillary attraction, and which for water is .1072 inch. The table begins with the extreme ordinate, where the curve is vertical: we have then the least ordinate, a; the greatest ordinate, where the curve again becomes horizontal, and the absciss corresponding to the extreme ordinate and to the greatest ordinate.

Extreme Ordinate.	Least Ordinate.	Greatest Ordinate.	Greatest Absciss.	Terminal Absciss.
$100\sqrt{r}$	99.99	100.01	.01	.000001
90	89.99	90.01	.01	.000002
80	79.99	80.01	.01	.000003
70	69.99	70.01	.01	.000004
60	59.99	60.02	.02	.000007
50	19.98	50.02	.02	.00001
45	44.98	45.02	.02	.00002
40	39.97	40.02	.02	.00003
35	34.97	35.03	.03	.00004
30	29.96	30.03	.03	.00006
25	24.96	25.04	.04	.0001
20	19.95	20.05	.05	.0002
15	14.93	15.07	.07	.0004
10	9.90	10.10	.10	.001
9	8.89	9.11	.11	.002
8	7.87	8.12	.13	.003
7	6.85	7.14	.14	.004
6	5.83	6.16	.17	.007
5	4.79	5.19	.21	.01
4	3.74	4.24	.26	.02
3	2.64	3.32	.37	.06
2	1.41	2.45	.65	.22
1.9	1.27	2.37	.71	.27
1.8	1.11	2.29	.79	.33
1.7	.94	2.21	.91	.47
1.6	.75	2.13	1.10	.65
1.5	.50	2.06	1.40	.96
1.47	.40	2.04	1.64	1.18
1.445	.30	2.02	1.86	1.44
1.428	.20	2.01	2.24	1.82
1.418	.10	2.003	2.92	2.49
1.4142	.01	2.000	5.22	4.80
1.4142	.001	2.0000	7.52	7.09
1.4142	.0001	2.0000	9.82	9.39
1.4142	.00001	2.0000	12.12	11.70
1.4142	.000001	2.0000	14.43	14.00

It may be observed that the last six values of the least ordinate are in geometrical progression, while the absciss increases in arithmetical progression; the difference of the abscisses 2. 3, being the hyperbolical logarithm of 10, which is the common multiplier of the ordinates. Although the table appears to be generally accurate, yet we cannot always depend on the last figures: thus the ultimate difference of the two last columns is made .43, while it ought to be .53 (Prop. B. Cor. 1). It is scarcely necessary to remark, that if we look, in the fourth column, for half the distance between two parallel planes of glass, in a vertical position, the first and second columns will give us the height to which water will rise between them, where it touches the glass, and in the middle of the interval.

Section IV.—*Surfaces of Double Curvature.*

When the liquid is contained in a tube, or when it forms itself spontaneously into a drop having an axis of revolution, it becomes necessary to consider the effect of the tension in a direction transverse to that of the principal section; since the curvature will cause it to exhibit an equal pressure, whatever the direction of the section to which it belongs may be; and the curvatures of the sections perpendicular to each other will either cooperate with, or counteract each other, accordingly as the convexities of both are on the same side, or on the opposite sides, of the surface. But the simple consideration of the tension, supporting the weight of the parts below, or the equivalent pressure in a contrary direction, will at once afford us the equations necessary for the solution of the problem, without any immediate reference to the curvature in question.

D. *The form of a surface of revolution may be determined by means of an infinite series.*

The fluxion of the weight or mass of the parts, contained within the cylindrical surface, of which x is the radius or absciss, and y the ordinate, being always proportional to $yx\mathrm{d}x$, and the fluent to $\int yx\mathrm{d}x$; and the extent of the circumference supporting it varying also as x, and the contractile force being diminished, when reduced to the direction of gravitation, in the ratio of the radius unity to the sine of the elevation s, it will always be proportional to xs; so that we have the general equation $\int yx\mathrm{d}x = mxs$. Now if we suppose y incomparably greater than x, and the surface extremely minute, the variation of y may be neglected, and we have in this case $\int yx\mathrm{d}x = \frac{1}{2}yx^2$: and supposing also $s = 1$, and the curve vertical, $\frac{1}{2}yx^2 = mx$, and $\frac{1}{2}yx = m$; x becoming also equal to the radius of curvature: but it is easy to perceive that the height y must be twice as great, for any value of x, as in the case of a simple curvature, since each portion of the circumference has here only to support a wedge, which is only half as heavy as a parallelepiped of the same height; so that $\frac{1}{2}yx$ will be equal to yx in Proposition A, and $m = r$.

In order to obtain a series for finding y, from the equation $\int yx\mathrm{d}x = mxs$, we may put the tangent $t = \frac{\mathrm{d}y}{\mathrm{d}x} = bx + cx^3 + dx^5 + \ldots$, whence $y = a + \frac{1}{2}bx^2 + \frac{1}{4}cx^4 + \frac{1}{6}dx^6 + \ldots$, and $\int yx\mathrm{d}x = \frac{1}{2}ax^2 + \frac{1}{2.4}bx^4 + \frac{1}{4.6}cx^6 + \frac{1}{6.8}dx^8 + \ldots$; and the value of $s = \frac{t}{\sqrt{(1+tt)}}$ being expanded into a series, as in Proposition C. n 6, calling $\frac{1}{m}$, or $\frac{1}{r}$, q, we find $s =$

$$\frac{q}{x}\int yx\mathrm{d}x = bx + cx^3 + dx^5 + ex^7 + \ldots$$

$$-\tfrac{1}{2}b^3x^3 - \tfrac{1}{2}\cdot 3b^2cx^5 - \tfrac{1}{2}\left\{\begin{matrix}3b^2d + \\ 3bc^2\end{matrix}\right\}x^7 + \ldots$$

$$+ \tfrac{3}{8}b^5x^5 + \tfrac{3}{8}\cdot 5b^4c\,x^7 + \ldots$$

$$- \tfrac{5}{16}b^7\,x^7 - \ldots$$

$$= \tfrac{1}{2}qax + \frac{1}{2.4}qbx^3 + \frac{1}{4.6}qcx^5 + \frac{1}{6.8}qdx^7 + \ldots;$$

consequently $b = \frac{1}{2}qa = \frac{a}{2r}$, and $a = \frac{2b}{q} = 2rb$, and

Cohesion.

by continuing the calculation and reducing the values, we find

$$c = \frac{1}{2.4}\, q\, b + \tfrac{1}{2} b^3$$

$$d = \frac{1}{2.4^2.6}\, q^2 b + \frac{10}{2.4.6}\, q b^3 + \frac{3}{2.4}\, b^5$$

$$e = \frac{1}{2.4^2.6^2.8}\, q^3 b + \frac{82}{2.4.6^2.8}\, q^2 b^3 + \frac{105}{2.4.6.8}\, q b^5 + \frac{15}{2.4.6}\, b^7$$

$$f = \frac{1}{2.4^2.6^2.8^2.10}\, q^4 b + \frac{652}{2.4.6^2.8^2.10}\, q^3 b^3 + \frac{2645}{2.4.6.8^2.10}\, q^2 b^5 + \frac{1260}{2.4.6.8.10}\, q b^7 + \frac{105}{2.4.6.8}\, b^9$$

$$g = \frac{1}{2.4^2.6^2.8^2.10^2.10}\, q^5 b + \frac{5197}{2.4.6^2.8^2.10^2.12}\, q^4 b^3 + \frac{59855}{2.4.6.8^2.10^2.12}\, q^3 b^5 + \frac{70522.5}{2.4.6.8.10^2.12}\, q^2 b^7 + \frac{17325}{2.4.6.8.10.12}\, q b^9 + \frac{945}{2.4.6.8.10}\, b^{11}$$

$$h = \frac{1}{2.4^2.6^2..12^2.14}\, q^6 b + \frac{41800}{2.4.6^2.8^2..12^2.14}\, q^5 b^3 + \frac{1303034}{2.4.6.8^2.10^2.12^2.14}\, q^4 b^5 + \ldots$$

$$i = \frac{1}{2.4^2.6^2..14^2.16}\, q^7 b + \frac{339412}{2.4.6^2.8^2..14^2.16}\, q^6 b^3 + \ldots$$

$$k = \frac{1}{2.4^2.6^2..16^2.18}\, q^8 b + \frac{2779888}{2.4.6^2.8^2..16^2.18}\, q^7 b^3 + \ldots$$

$$l = \frac{1}{2.4^2.6^2..18^2.20}\, q^9 b + \frac{22941328}{2.4.6^2.8^2..18^2.20}\, q^8 b^3 + \ldots$$

We may here observe, that the numerical coefficients of the highest powers of b form the series $\frac{1}{2}$, $\frac{3}{2.4}\cdot\frac{3.5}{2.4.6}\cdot\frac{3.5.7}{2.4.6.8}\cdot\frac{6}{6}\cdot\frac{3.5.7.9}{2.4.6.8.10}\cdot\frac{8}{6}$, the ratio of the successive terms of both continually approaching to equality; and those of the next in order the series $\frac{3}{2.4}\cdot\frac{2}{6}\cdot\frac{3.5}{2.4.6}\cdot\frac{4}{6}\cdot\frac{3.5.7}{2.4.6.8}$: but the laws of the numerical coefficients in general appear to be wholly incapable of being reduced to any simple form. It will be convenient for calculation to form tables of the logarithmic values of these coefficients, which may be continued, by means of successive differences, for as many terms as are requisite for any practical purpose. The indices, with lines drawn over them, are to be considered as negative numbers.

Logarithmic Coefficients of the Value of the Sine. Cohesion.

$s = (\ 0.\ 0000000$
$+\overline{1}.\ 0969100\, qx^2$
$+\overline{3}.\ 7166987\, q^2x^4$
$+\overline{4}.\ 0354574\, q^3x^6$
$+\overline{6}.\ 1323674\, q^4x^8$
$+\overline{8}.\ 0531861\, q^5x^{10}$
$+\overline{11}.\ 8278768\, q^6x^{12}$
$+\overline{13}.\ 4776288\, q^7x^{14}$
$+\overline{15}.\ 0182362\, q^8x^{16}$
$+\overline{18}.\ 4619336\, q^9x^{18}$
$+\overline{21}.\ 8184809\, q^{10}x^{20}$
$+\ldots)\, bx$
$+\overline{2}.\ 3187587\, qx^2$
$+\overline{3}.\ 6375174\, q^2x^4$
$+\overline{4}.\ 6482413\, q^3x^6$
$+\overline{5}.\ 4694937\, q^4x^8$
$+\overline{6}.\ 1456895\, q^5x^{10}$
$+\overline{8}.\ 7008651\, q^6x^{12}$
$+\overline{9}.\ 15102$[illegible]$4\, q^7x^{14}$
$+\overline{11}.\ 5080209\, q^8x^{16}$
$+\overline{13}.\ 7811595\, q^9x^{18}$
$+\overline{15}.\ 9774\ldots q^{10}x^{20}$
$+\overline{16}.\ 1026\ldots q^{11}x^{22}$
$+\overline{18}.\ 160\ldots q^{12}x^{24}$
$+\overline{20}.\ 16\ldots q^{13}x^{26}$
$+\overline{22}.\ 10\ldots q^{14}x^{28}$
$+\overline{24}.\ 0\ldots q^{15}x^{30}$
$+\ldots)\, b^3x^3$
$+(\overline{3}.\ 8927900\, qx^2$
$+\overline{3}.\ 5337080\, q^2x^4$
$+\overline{4}.\ 8558231\, q^3x^6$
$+\overline{5}.\ 9851885\, q^4x^8$
$+\overline{6}.\ 9727959\, q^5x^{10}$
$+\overline{7}.\ 82\ldots q^6x^{12}$
$+\overline{8}.\ 57\ldots q^7x^{14}$
$+\overline{9}.\ 27\ldots q^8x^{16}$
$+\overline{11}.\ 97\ldots q^9x^{18}$
$+\overline{12}.\ 77\ldots q^{10}x^{20}$
$+\ldots)\, b^5x^5$
$+(\overline{3}.\ 5917600\, qx^2$
$+\overline{3}.\ 4368580\, q^2x^4$
$+\overline{4}.\ 9595058\, q^3x^6$
$+\ldots b^7x^7$
$+\overline{3}.\ 3576767\, qx^2$
$+\overline{3}.\ 3498514\, q^2x^4$
$+\ldots)\, b^9x^9$
$+(\overline{3}.\ 1657913\, qx^2$
$+\ldots)\, b^{11}x^{11}$
$+\ldots$

Logarithmic Coefficients of the Value of the Ordinate y.

$y = \left[\frac{2b}{q}\right] + 0.\ 6989700$
$+\overline{2}.\ 4948500\, qx^2$
$+\overline{4}.\ 9385474\, q^2x^4$
$+\overline{5}.\ 1323674\, q^3x^6$
$+\overline{7}.\ 1323674\, q^4x^8$
$+\overline{10}.\ 9740048\, q^5x^{10}$
$+\overline{12}.\ 6817488\, q^6x^{12}$
$+\overline{14}.\ 2735087\, q^7x^{14}$
$+\overline{17}.\ 7629636\, q^8x^{16}$
$+\overline{19}.\ 1609036\, q^9x^{18}$
$+\ldots)\, bx^2$
$+(\overline{1}.\ 0969100$
$+\overline{2}.\ 5406074\, qx^2$
$+\overline{3}.\ 6482413\, q^2x^4$
$+\overline{4}.\ 5486749\, q^3x^6$
$+\overline{5}.\ 2918175\, q^4x^8$
$+\overline{7}.\ 9049851\, q^5x^{10}$
$+\overline{8}.\ 4062959\, q^6x^{12}$
$+\overline{10}.\ 8090509\, q^7x^{14}$
$+\overline{11}.\ 1235822\, q^8x^{16}$
$+\overline{13}.\ 3576\ldots q^9x^{18}$
$+\overline{15}.\ 5176\ldots q^{10}x^{20}$
$+\overline{17}.\ 607\ldots q^{11}x^{22}$
$+\overline{19}.\ 637\ldots q^{12}x^{24}$
$+\overline{21}\ 60\ldots q^{13}x^{26}$
$+\overline{23}.\ 5\ldots q^{14}x^{28}$
$+\ldots)\, b^3x^4$
$+\overline{2}.\ 7958800$
$+\overline{2}.\ 5337080\, qx^2$
$+\overline{3}.\ 9350043\, q^2x^4$
$+\overline{3}.\ 1313165\, q^3x^6$
$+\overline{4}.\ 1769159\, q^4x^8$
$+\overline{5}.\ 08\ldots q^5x^{10}$
$+7.\ 87\ldots q^6x^{12}$
$+\overline{8}.\ 51\ldots q^7x^{14}$
$+\overline{9}.\ 35\ldots q^8x^{16}$
$+\overline{10}.\ 18\ldots q^9x^{18}$
$+\ldots)\, b^5x^6$
$+\overline{2}.\ 5917600$
$+\overline{2}.\ 6709412\, qx^2$
$+\overline{2}.\ 1056338\, q^2x^4$
$+\ldots)\, b^7x^8$
$+(\overline{2}.\ 4368579$
$+2.\ 4959794\, qx^2$
$+\ldots)\, b^9x^{10}$
$+(2.\ 3119193$
$+\ldots)\, b^{11}x^{12}$
$+\ldots$

Cohesion.

E. *The elevation or depression of a liquid contained in a given tube may be found by reversing the series.*

Having a given value of x, the semidiameter of the tube, and also of s, the elevation or depression of the surface of the liquid at the point of contact with the solid, we obtain an equation of the form $s = \mathrm{A}b + \mathrm{B}b^3 + \mathrm{C}b^5 + \ldots$, and from this we may determine the central elevation or depression $a = 2rb$ by the well known method of the reversion of series, which give us the value $b = \frac{1}{\mathrm{A}} s - \frac{\mathrm{B}}{\mathrm{A}^4} s^3 - \left(\frac{\mathrm{C}}{\mathrm{A}^6} - \frac{3\mathrm{B}^2}{\mathrm{A}^7}\right) s^5 - \left(\frac{\mathrm{D}}{\mathrm{A}^8} - \frac{s\,\mathrm{BC}}{\mathrm{A}^9} + \frac{12\,\mathrm{B}^3}{\mathrm{A}^{10}}\right) s^7 - \ldots$ But it is more convenient to assume an approximate value of b, a little less than $\frac{s}{\mathrm{A}}$, and to find the corresponding value of s; then since $ds = \mathrm{A}db + 3\,\mathrm{B}b^2 db + 5\,\mathrm{C}\,b^4 db + \ldots$, if we make $\mathrm{A}b + 3\,\mathrm{B}\,b^3 + 5\,\mathrm{C}\,b^5 + \ldots = \Sigma$, we shall have $\frac{ds}{db} = \frac{\Sigma}{b}$; consequently the small increments of s and b will be to each other as Σ to b, and we obtain the correction of b from the error of the calculated value of s: and if the calculation be repeated with the corrected value of b, the second result will always be sufficiently near to the truth.

In order to judge of the accuracy of this mode of calculation, which Mr Laplace appears to have thought liable to some undefined objection, it will be necessary to enter into the details of its different elements, which will sufficiently show the degree of convergence of the series, and the greatest possible amount of error.

Values of the Coefficients of s for Tubes of different Diameters, r being .005, and s = .75.

$\mathrm{D} = 2x$	$s = bx\times$	$+b^3x^3\times$	$+b^5x^5\times$	$+b^7x^7\times$
1.0	47.176	7190		
.8	15.774	274		
.6	5.737	13.214	200	
.4	2.399	.8556	1.625	
.2	1.2717	.06311	.03693	.0311
.1	1.0638	.01155	.00486	.00278

Hence if

$b =$	$s =$
0.3073	.7248 + .0252
.1147	.7237 + .0265
.4160	.7160 + .0254 + .0060 + [.0026]
1.503	.7211 + .0240 + .0041 + [.0010]
5.776	.7345 + .0122 + .0024 + .0007 + [.0003]
14.004	.7449 + .0040 + .0008 + .0002 + [.0001]

It appears upon inspection of this table, that the coefficients of bx alone always determine $\frac{29}{30}$ of the value of the quantity required, and these are easily calculated with perfect accuracy, so that the error must always be far less than $\frac{1}{30}$, and in fact the actual uncertainty never exceeds $\frac{1}{1000}$ of the whole, at least in the last four examples. The differences of Mr Laplace's approximatory calculations from these results are incomparably greater, so that we cannot hesitate to consider these differences as errors. Indeed, when we recollect that in the method employed by Mr Bouvard, under Mr Laplace's directions, the radius of curvature of each of the small portions, into which the curve has been cut up, has been determined from the ordinate at the beginning of the portion, it is obvious that the curvature thus found must be less than the truth, and that in order to obtain any required curvature of the whole surface, the depression must be increased in the same proportion: and there is no ready way of appreciating the amount of this error. Dr Young had before attempted to avoid it, in making an estimate of the same nature, by calculating for the middle of each portion; but from some accident, the numbers of his table, published in 1807, are generally a little too small, although the method, which he then employed, is nearly the same as that which Mr Laplace afterwards adopted; except that for the lowest portion of the curve, Mr Laplace had recourse to an infinite series, applicable only to that part. The elements deduced in Nicholson's journal for 1809, from Mr Gay Lussac's experiments, which are $r = .0051$ and $s = .7353$, agree better with the numbers found in Mr Laplace's table, than those from which it was constructed, which were $r = .005038$ and $s = .729$; the depressions being always a little larger than the true results from the elements assumed.

The value of the ordinate y depends also principally on the first variable member of the series, although the subsequent coefficients are not so inconsiderable as in the determination of the sine. Thus taking $x = .2$, and $b = 1.503$, we have $y = a + .813\,bx^2 + .99\,b^3x^4 + 2.97\,b^5x^6 + \ldots = .01503 + .0489 + .0054 + .0015 + [.0006] = .0714$, which is the marginal depression, leaving .0564 for the height of the convex portion $y - a$. We may determine the effect of any small variations in this height, in the same manner as that of the sine of the inclination: supposing them to depend on a change of the angle of contact only, the quantity r remaining unaltered, it is obvious that q and x must retain their value, while y and b only vary; and making $\mathrm{Y} = \mathrm{A}b + 3\,\mathrm{B}b^3 + \ldots = b\frac{d\,(y-a)}{db}$, we have $\mathrm{Y} : b = d\,(y-a) : db$. In the present instance, we find $\mathrm{Y} = .0489 + 3 \times .0054 + 5 \times .0015 + \ldots = .079$; and supposing, as in the example suggested by Mr Laplace, the variation of the height $y - a$ to be .00394, which is $\frac{1}{20}$ of Y, that of b will be $\frac{1}{20}$ of b, or .075, and the variation of the central depression a, .00075, which is somewhat less than one fifth of the alteration in the height of the convex portion: but in smaller tubes it is obvious that the variations of the depression a might much exceed that of the height of the convex portion. Nothing can be easier or more direct than this part of the calculation; and it is remarkable that Mr Laplace should have considered the awkward contrivance of building up a curve, like the arch of a bridge, with fourteen blocks on each side, as possessing any thing like an "advantage" over the series in the determination of this variation.

If we wish to find the effect of a small variation of the diameter of a tube, from D to D ± D′, on the depression a of the mercury contained in it, we may

Cohesion.

use for the interpolation the formula $\frac{a'}{a} = 10^{CD'} - 1$, C being about 2.9 for tubes between 1 inch and $\frac{1}{5}$th of an inch in diameter, and being elsewhere easily deduced from the depressions already known. For variations of the cohesive power, and of its measure r, we may suppose the whole of the numbers of the table to be altered in the proportion of the supposed alteration of $\sqrt{r}$, and the change produced by restoring the diameter to its former dimensions may then be calculated like any other interpolation. There is also a more comprehensive formula, which seems to express the depression in tubes of all sizes with great accuracy; it is this, $a = \frac{.015}{D + 48 D^{3.492 + 3.26 D}}$: and it might even be possible to shorten the original calculation by a comparison of the series with the expansion of this empirical formula, if it were of any further importance to facilitate the mode of computation. But for all practical purposes, it will be sufficient to collect the results already obtained into a comparative table, arranged in chronological order: and it is remarkable, that they are all comprehended, without any material exception, between the two values assigned to each as near the truth in Dr Young's first table, the mean of those values never differing a thousandth of an inch from the result of the more correct calculation; while the error of Lord Charles Cavendish's experiments, notwithstanding their general accuracy, sometimes amounts to nearly one hundredth.

Table of the Depression of Mercury in Glass Tubes.

DIAMETER.	CENTRAL DEPRESSION.											MARGINAL DEPRESSION.	DIFFERENCE.	DIAMETER.
	Observed by Ld Cavendish.	Dr Young, Phil. Trans. 1805.		Laplace, 1806.	Dr Young, 1807.	Nicholson's Journal, 1809.		Laplace, 1810.	Correct Calculation.		Empirical Formula.	Nich. 1809.		
Inches.		Diagr.	Form.			$r = .005$ $s = .750$	$r = .0051$ $s = .7353$		$r = .005$ $s = .750$	$r = .005038$ $s = .729$		$r = .005$ $s = .750$		
1.00						.00031	.00032		.0003073	.000307	.00031			1.00
.90						.00060	.00062				.00059			.90
.80						.00115	.00118	.00128	.001147	.001144	.00112			.80
.70						.00220	.00224	.00244			.00220			.70
.60	.005	.005		.0038	.0045	.00411	.00416	.00462	.004160	.04128	.00421	.0637	.0596	.60
.50	.007	.007	.008		.0074	.00799	.00805	.00868			.00799	.0676	.0596	.50
.45					.0100	.01100	.01106	.01174			.01099	.0690	.0580	.45
.40	.015	.012	.017	.0136	.0139	.01516	.01522	.01591	.01503	.01486	.01495	.0714	.0562	.40
.35	.025	.017	.024		.0196	.02093	.02098	.02165			.02082	.0745	.0536	.35
.30	.036	.027	.033		.0280	.02902	.02906	.02965			.02881	.0787	.0497	.30
.25	.050	.038	.044		.0404	.04064	.04067	.04117			.04025	.0850	.0444	.25
.20	.067	.056	.061		.0589	.05800	.05802	.05798	.05776	.05696	.05771	.0966	.0386	.20
.15	.092	.085	.088		.0880	.08620	.08621	.08538			.08568	.1171	.0309	.15
.10	.140	.140	.140		.1424	.14027	.14027	.13940	.14004	.13726	.14002	.1619	.0216	.10
.05					.2964	.29497	.29497				.29502	.3060	.0110	.05

(F. O.)

COINAGE.

UNDER this head it will be proper to give a brief account of the constitution of the Royal Mint, as well as of the different processes which come under the general term *Coinage*; for all these processes are conducted under various checks emanating from the constitution which the legislature has thought proper to give this Royal Establishment.

The Royal Mint attained its constitution of superior officers in the 18th year of the reign of Edward II., and, with very few alterations, continued as then established till the year 1815. Of the alterations in this latter year we shall have occasion to speak hereafter.

Ancient Establishment of the Mint.

Edward appointed a Master, Warden, and Comptroller, King's and Master's Assay Master, and King's Clerk, besides several inferior officers, whose duties will be mentioned hereafter. Previous to this period, we have very little information as to the system of coinage pursued at the various mints which the kings of England had throughout their dominions. The Rev. Roger Rudding, in his valuable and laborious *Annals of the Coinage of Britain and its Dependencies*, gives it as his opinion, that the moneyers were in very early ages the only officers employed in the fabrication of the money. On the early Anglo-Saxon coins are found, besides the names of the monarchs, those of other persons, who are with great probability conjectured to have been the moneyers, because on the later Anglo-Saxon money the names of those officers frequently occur, with the addition of their title of office. From the circumstance of their names being inscribed on the coins, it is reasonable to conclude, that they were responsible for the integrity of the money, and that likewise they were the principal officers of the mint, because inferior officers would have given security to their superiors, whose names would have appeared on the money, as a pledge to the sovereign that it

was duly executed. The silence also of the Anglo-Saxon laws, and of *Doomsday Book*, as to other officers of the mint, whilst they so frequently mention the moneyers, greatly corroborates the opinion, that they were the only persons employed in the Anglo-Saxon and early Anglo-Norman mints, except, perhaps, occasional labourers; and it is observable, that, when in the reign of Henry I. the money was so much corrupted as to call for a sentence of the most exemplary severity on the offenders, the punishment is said to have been inflicted upon moneyers only, without the least notice of any other officer. This was also the case upon a similar occasion in the reign of Henry II.

Mr Rudding is unable to determine the exact period when it became necessary to place some permanent superintending authority in the mint to prevent the bad practices of the moneyers; but it is probable, he says, that such an officer was appointed between the 26th of Henry II., when the moneyers alone were punished for the adulteration of the money, and the 3d of Richard I., when Henry de Cornhill accounted for the profits of the cambium of all England, except Winchester.

It is not improbable that this first warden of the mint was appointed for the purpose of collecting the revenue arising from the seignorage charged upon coinage of bullion.

The object of the warden's appointment might also extend to the inspection of the fabrication of the money, with a view to prevent the master and his moneyers, or the moneyers alone, from taking any undue advantage of the king, or the public, by the adulteration of the coin. The most important officer, however, upon the establishment of the mint, with a view to the maintenance of the standard purity of the coin, is the king's assay master: and there are persons mentioned as holding this office in the 6th of Henry III. As this officer had the assaying of all the bullion after melting for coinage, and after it was coined, it is obvious that the very existence of the credit and honour of the mint and sovereign depended upon the duties he had to perform; and such an officer probably existed from the earliest period of the fabrication of money, though our records do not accurately define the precise date of his appointment.

The next officer of importance in the mint is the comptroller; and the first whom Mr Rudding's researches have discovered, held the office between 5th and 15th of Edward II. His duty, distinct from that of the other officers of the mint, is to make out annually a roll, called usually the comptroll or comptrollment roll, containing an account of all the gold and silver coined, and to deliver it on oath before one of the Barons of the Exchequer. It is always written upon parchment, and forms a permanent record of the coinages of the mint.

The king's clerk and clerk of the papers is the next check officer upon the establishment; as king's clerk, he acts as a check upon the whole process of the coinage, the same as the warden and comptroller; as clerk of the papers, he keeps a book of record of the transactions of the mint. Of the creation of this office we have not been able to find any record.

These are the principal check officers of the mint, and, no doubt, were appointed as mutual checks upon each other's integrity, and to watch over the interests of the king and other importers of bullion into the mint.

There is another officer upon the establishment, whose duties are important, but of whose origin and appointment we have not been able to find any notice. His title is, the master's assay master, and his duty consists in assaying every ingot of gold and silver brought to the mint for coinage; and upon his integrity the master and worker relies that no bullion shall be received into the office for coinage, but what is conformable to the standard of the realm.

Mr Rudding remarks, Vol. III. p. 1. that, at a very early period of the history of Britain, when the communication between its different parts was extremely imperfect, it became necessary to establish mints and exchanges, not only in the chief city, but also in various other places, for the purpose of supplying the neighbouring districts with money to carry on their commerce. To this necessity alone such establishments are to be ascribed; and accordingly we find that, by degrees, as the communication opened, the subordinate mints and exchanges sunk into disuse, and one fixed in the metropolis was found to be amply sufficient for the supply of the whole kingdom.

Athelstan appears to have been the first monarch who enacted any regulations for the government of the mints. In his laws, which were promulgated about the year 928, he provided that one sort of coin only should be current throughout the kingdom, and granted to various towns, by name, a number of moneyers proportionate to their size and consequence, and to all boroughs of inferior rank one moneyer each.

These mints were under the control of that within the Tower of London, from which, as paramount, the dies were issued; and for which the moneyers paid a regular fee upon every alteration of the coins. They also paid an annual rent, which, in the city of Lincoln, amounted to L.75 (according to the statement of *Doomsday Book*), a very considerable sum at that time. The rents of the other mints were, however, much inferior to this.

To increase the facility of distributing the coins made at these mints, Exchanges were appointed in various places from whence the new coins were issued, and in which bullion was purchased for the supply of the mint; and it appears that our monarchs claimed the exclusive privilege of purchasing bullion, and appointed proper officers, to whom they delegated that branch of their prerogative.

It appears to have been the duty of these officers, not only to exchange the current coins of one metal for those of another, but also to receive wrought plate and bullion, and foreign coins, according to their fineness respectively; and as the exportation of the coins of the realm was prohibited, they furnished persons going out of the kingdom with foreign coins, in exchange for English, and also supplied merchants and strangers coming into the kingdom with English coins in exchange for foreign. These exchanges of coin were regulated by a table, which was hung up in the exchanger's office.

This office has ceased to exist since the reign of

Coinage.

Charles I. Henry Earl of Holland was the last keeper of the exchanges between England and Ireland.

Besides the officers mentioned, there was another of great importance in early times, who bore the title of Cuneator. Mr Rudding mentions this officer as being hereditary, and, as far as he had discovered, the only one in the mint that was so. The engravers of the dies seem to have been appointed by him, and to have been under his immediate cognizance. By him they were presented to the Barons of Exchequer, before whom they took the usual oath of office; and it was probably his duty to see that all the dies (as well those which were used in the paramount mint, in the Tower of London, as those which were issued from thence to the subordinate mints) were of the same type. This was no doubt a circumstance of great moment, when so many mints were allowed to be worked in various parts of the kingdom. When these mints were abolished, and the mint in the Tower became the only source from whence coins were derived, the office sunk into disuse. By right of office, this officer claimed the old and broken dies as his fee. An officer of a similar kind exists in the mint at this day, who is called clerk of the irons, whose duty it is to superintend the manufacture of the dies for coinage; but he has no power to appoint the engravers of the dies.

In the early history of the mint, as at present, the master of the mint fabricated the coins at certain charges *per* pound weight. He had his regular establishment of melters and moneyers, to whom he paid certain rates for melting and making the monies, reserving for himself a certain fee for his trouble and responsibility. For, in all his engagements with the Crown, the master had to bear all waste and charges arising in and out of the coinage of gold and silver. Mr Rudding mentions that, in the 10th of Edward III. the workmen of the mint of London petitioned the king for an increase of their allowance for coinage; alleging that they were at that time at greater expence, and bestowed more labour, in forming the monies, than had been usual in former times, so that they could not maintain and continue such expence and labour, unless their allowance was increased.

The king being willing to grant their petition if just, commanded John de Wyndesore, warden of the mints of London and Canterbury, together with Lapone Roger, and others experienced in such matters, to inquire whether the allowance was sufficient; and if not, to determine what addition should be made; and they were ordered to make their report in Chancery, under their seals, without delay.

A warrant was in consequence issued, and Lapone and Roger Rikeman, exchangers of London, and Stephen Boke, having been examined on oath by the warden, the following report was made: That, having inquired diligently respecting the necessary expences of the master of the mint and the workmen, viz. of alloy, clay, and salt, and other things used in the making of new money, and also of the expences occasioned by the waste arising from the whitening of the halfpennies and farthings, on account of the increase of the alloy, and from the hardening of the metal of the said coins in working and coining—they were of opinion that the work could not be carried on without an increase of 3d. for each pound at the least; and with that the workmen ought reasonably to be contented. Then, whereas of old they received for all costs, colour, &c. for a pound of halfpennies, $7\frac{1}{2}$d., and for a pound of farthings, $9\frac{1}{2}$d., they would receive for the former $10\frac{1}{2}$d., and for the latter $12\frac{1}{2}$d., so that the master should have of increase 2d., and the workmen 1d.

It was the duty of the warden to take an account of all the bullion of gold and silver entrusted to the master and worker of the mint to be coined; and in this duty he was aided by the comptroller and king's clerk, who in their respective capacities kept books of entries of the receipt of bullion, and its delivery in coin to those who brought the bullion for that purpose. Besides those duties, these check officers had the superintendence of the different processes throughw hich the bullion had to pass, from the assay of the ingot to the delivery of the coin to the importers; and it is more than probable, that in the infancy of the mint, and when the demand for coin was very limited, the whole processes of the coinage were conducted in one apartment; that the master, warden, comptroller, and other principal officers of the mint, accompanied the sovereign from place to place in his dominions, and actually superintended the fabrication of the coin at the mints of the towns where he sojourned. The progressive civilization of the country, the increasing demand for money, and the more permanent residence of the monarchs in London, give the mint of the Tower a predominancy over all others; and these circumstances very probably called for the appointment of other check officers, who are now upon the mint establishment; such as the surveyor of the meltings, whose duties are to superintend the melting of the pots of gold and silver, and to weigh the proportion of fine gold or alloy which may be necessary to produce the standard of the money; to take samples of all pots melted, and take them to the king's assay-master, for him to ascertain if the standard has been adhered to by the melter; and to lock up the said pots, of which samples have been taken, in the melter's strong-hold, of which he has one key, and the melter another, and there to retain them until the king's assay-master has declared that they are of the proper standard. In the infancy of the mint, the duties of this officer were probably performed in the presence of the warden, comptroller, and king's clerk; but the increase of duties in the mint office, in the receipt of bullion and delivering coin, probably rendered it necessary to relieve the principal officers from these duties, as well as from those of another officer, called the surveyor of the money-presses, whose duties consist in seeing that good dies are used, and clean money made in the coining room.

When these and other officers were in full power, operating as checks upon the coinage, and, consequently, upon the master and worker, they received their salary and fees from the warden, as chief of the check branch of the establishment.

The expenditure for the repairs of buildings, offi-

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cers' houses, &c. &c. was also paid by the warden of the mint; and his authority for doing so was by the mint indenture, in which these duties are detailed. "And our said Sovereign Lord the King doth will and command, that the warden or wardens of the mint, for the time being, shall content and pay to the officers and ministers aforesaid, such stipends and wages, and such diet, as in schedule limited and appointed, in manner and form, and during such term as in the same expressed; and that thereof he and they shall have due allowance and defalcation upon his or their accounts. And that the said warden or wardens shall make his or their accounts yearly, as well of all and every of his or their receipts, as of his or their payments, and other charges, before the auditors of the mint for the time being, unless it shall please his Majesty otherwise to appoint the same; in which account the same auditors, or others to be appointed by his said Majesty to take the said accounts, shall make unto the said warden or wardens full allowance, defalcation, and discharge, as well for all such sum and sums of money as he or they shall duly prove to have been paid or disbursed for officers' fees and wages, and diet for the said officers, as for any other necessary charges to be employed in and about the making of the said monies, or the repairing of the said offices and houses, necessarily to be employed in the said service, under the avouchment of the said master and comptroller and assay-master, or any two of them, whereof the said master is to be one; and the said accounts so to be made by the said auditors, or by any other of his Majesty's special appointment for the same, being stated, and his debts determined, and his said accounts fully answered to his Majesty, the said warden or wardens, upon his or their suit to the Lord Chancellor, or Lord Keeper of the Great Seal, or Commissioners of the Great Seal, shall have letters patent of his said Majesty under the great seal, to be made on his or their acquittance, without fee therefor paying; for the making of which said letters patent, these presents shall be a sufficient warrant and discharge to the said Lord Chancellor, or Lord Keeper, or Lords Commissioners for the custody of the Great Seal, for the time being, without any further or special warrant to be sued out for the same."

Notwithstanding the number of the checks upon the coinage of our money, its history gives us the most undeniable proofs of their inefficiency, when the arbitrary will of the sovereign was allowed to put all law and justice aside. However much we may admire the precautions used by our ancestors in the formation of the constitution of the mint, we have still the painful recollection (though its forms and regulations have existed since the reign of Edward III.) that they could not prevent a Henry VIII. from disgracing his reign by, perhaps, the most wanton debasement of the currency, that was ever, in a similar period of time, practised in any country in the world. The same ignorance and injustice disgraced the beginning of the reign of his son, Edward VI., but the subsequent acts, even of his short reign, were a good apology for the impolicy of his measures, and the severest censure upon the injustice of his father's acts regarding the currency. The short reign of Edward VI. prevented that thorough reformation in the currency which the wisdom of his measures began, and which was perfected in the long and glorious reign of his successor, Elizabeth.

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Expences of the Coinage in early times.

In the early history of our coinage, its expences were paid by a duty or seignorage upon the money coined; and, besides these expences, a certain duty was retained for the sovereign, and was one of the sources of his revenue. The amount of this duty was regulated entirely by the will of the sovereign, and without any regard to the principle by which it was assessed; it varied in different reigns, and was probably, in a great measure, regulated by the necessities of the sovereign for the time being. The mere charge of coinage, as Mr Rudding justly remarks, is probably as ancient as the invention of coined money; because it would soon be discovered, that the sovereign, after having turned his bullion into coins, for the benefit of his subjects, was no richer than before. It is probable, however, that the deduction did not remain long at the simple expence of coinage, but was soon made a profitable and easily collected source of revenue. In fact, the prerogative of coinage being exclusively the sovereign's, made it a certain source of revenue. In the earliest mint accounts which Mr Rudding has met with, viz. one of the 6th of Henry III., the profit upon the coinage was 6d. in the pound. This appears, says Mr Rudding, from the entries, under that year, of bullion coined in the mint at Canterbury, when the profit upon L. 3898, 4d. is stated to be L. 97, 9s., which is exactly 6d. in the pound. Of that sum the king had L. 60, 18s. $3\frac{1}{2}$d., and the archbishop L. 36, 10s. $10\frac{1}{2}$d. (these totals do not precisely agree, as is frequently the case when sums are stated in Roman numerals); the whole sum of L. 97, 9s. is stated to be the amount of *exitas lucri*, that is, we presume, the clear profit, after all the expences were deducted. And this will agree with the seignorage which was taken in the 28th year of Edward I., amounting to 1s. $2\frac{1}{2}$d. upon every pound, out of which the master had $5\frac{1}{2}$d. for all expences, and there remained 9d. clear profit to the king.

As this latter date is about seventy-eight years subsequent to the former, it is not improbable that the seignorage had been raised in that time, in the proportion of nine to six.

Regulations introduced by Charles II.

A seignorage continued to be charged upon the coinage of both gold and silver until the reign of Charles II., who, after his restoration, took the expences of the coinage of the money of the Commonwealth upon himself.

In September 1661, in the 13th year of his reign, a proclamation was issued, declaring, that the gold and silver coined during the period of the Commonwealth should not be current after the last day of November in the same year. At the same time it declared, "that such of our subjects in whose hands these moneys shall be found after the last day of November next ensuing, may not suffer too great damage or prejudice thereby, we are pleased further to declare, that all and every person and persons who shall bring any gold or silver coyn of the stamps and inscriptions aforesaid into our mint in the Tower of London, shall there receive

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the like quantity of lawful and current moneys, weight for weight, allowing only for the coinage."

On the 7th day of December in the same year, another proclamation was issued, declaring the money of the Commonwealth current only in payment of taxes, &c. to his Majesty, and to continue so to the 1st day of May next ensuing. The object of this proclamation was to bring as much of this money into his Majesty's exchequer as possible, for the purpose of recoining it. It is in this proclamation that the king takes the expence of coinage upon himself: "We being willing," it says, "for the ease of our subjects, to take the charge of the coinage thereof upon ourself."

It was in these proclamations that the system began of charging the government with the expences of the coinage of this country. The merchants and others, who were interested in saving both the duty and the expence of coinage, took advantage of the last mentioned proclamation, and represented to the king and his council by memorials, the great advantage which trade and the country at large would derive from the sovereign taking upon himself, as a permanent charge, the expence of coinage; they also represented that a great increase would take place in the quantity of money, if coined free of any charge to the importers of bullion. As these representations were irreconcilable with the just principles of public wealth,—as they were brought forward by persons ignorant of the consequences which would attend their execution, we much doubt whether they produced the effect which the interested individuals were so desirous of obtaining. In the 18th year of the same reign, an act was passed, exempting, in future, the importers of bullion from all charge of coinage, and which has continued till the present day.

As the science of political economy was very little understood in the period here mentioned, it is not to be wondered at, that the voices of a few interested individuals could procure the passing of an act so plausible. There can be no doubt but Charles and his council were swayed by the apparent knowledge which those individuals evinced in the practical details of business, and trusted to their representations being correct; but a practical knowledge of business, founded upon mistaken principles, must lead to erroneous conclusions; and it is easy to prove, that Charles and his council were imposed upon by these practical men.

This country would, at least, have been equally rich, and the quantity of coined money in no degree diminished, if the charge of workmanship had been continued upon the coinage; for the quantity of money in a country that possesses no mines of its own, must be regulated by the produce of its land and labour,—upon the quantity of exchangeable commodities; and as the quantity of exchangeable commodities increased, so would the quantity of money be increased, except in so far as good husbandry, or increased value of the precious metals could make it be spared to circulate them. As the charge of coinage could have no effect in diminishing the quantity of the precious metals that would be imported into the country; the portion of this bullion that would be brought to the mint to be coined, would depend upon the demand for coin; and this demand would regulate the profits, which the individuals, who did coin, could make by it, either in trading with it themselves, or by lending it to others.

If there were a charge for coinage, there would, strictly speaking, be a less quantity of bullion imported, because we should have a less quantity of money than we now have; but that money would be *more* valuable. A guinea or 5 dwts. $9\frac{1}{2}$ grs. would be more valuable than 5 dwts. $9\frac{1}{2}$ grs. of gold bullion, and consequently fewer of them would be requisite for the circulation of the same amount of commodities. The effect would, therefore, be to increase the quantity of commodities, and to lessen the quantity of bullion or coin.

Question as to the effects of a Seignorage.

The policy of Charles's measures with respect to the coinage, have been questioned by various writers. And, in fact, the principle of a seignorage, so often agitated, has never been satisfactorily settled. Lord Liverpool, in his excellent *Letter to the King upon the Coins of the Realm*, conceives that a seignorage upon our gold coin, which is the standard money of our country, would necessarily cause that measure of property to be imperfect. His Lordship has not favoured us with any account of the nature of the imperfection that would have been created by charging a seignorage upon our gold coins. The only imperfection that could be called into existence we apprehend, by charging the expence of coinage upon gold, would be the alteration which it would make in its value. L. 100 of gold coin, chargeable with an expence of coinage (say of $1\frac{1}{2}$ *per cent.*), would, while the king preserved the monopoly of coinage, be more valuable than its weight of uncoined gold; and consequently would alter the state of debtor and creditor, as well as require the Government to pay her annuitants, and other branches of her expenditure, in a currency more valuable than before the charge of seignorage was imposed.

Let us, for example, suppose that we had only coins of gold in this country, and that a seignorage to the amount of the expences incurred in their manufacture was imposed by the legislature, say of $1\frac{1}{2}$ *per cent.*, it must be evident that a L. 100 of such coins would be more valuable than their weight in bullion of the same purity, by the expence of the coinage. Every L. 100 of such gold currency, therefore, would purchase not only its weight of bullion, but $1\frac{1}{2}$ *per cent.* more, as the expence of converting such bullion into coin. As no legal coin can be obtained but where this charge is made, the market-price of gold would thus be $1\frac{1}{2}$ *per cent.* under its mint price. If the seignorage exceeded the expences of the coinage, so as to afford a profit to the illegal coiner, supposing him to coin money of the legal standard in weight and fineness, then would the value of the currency be reduced by such illegal additions to its quantity; the market price of bullion would approach to its mint price, but would fall short of it by the real expences of the coinage, and would thus destroy the profits of the illegal coiner It will also follow, that a L. 100 of such currency would purchase a greater quantity of any commodity than its weight of bullion of the same purity

would do, and that by the expences of the coinage, or $1\frac{1}{2}$ *per cent.* By the imposition of a seignorage, therefore, the price of bullion and commodities would experience a fall, limited however by the real expences of the coinage, no laws having yet been devised to prevent illegal additions to the currency. We should not however apprehend that the coins fabricated under this system would in any degree be imperfect: on the contrary, we think that a considerable national advantage might have been the result, had such a principle been adopted at the British mint. As the value of the coins would be increased, so would their quantity have been diminished. A smaller amount of currency would have circulated the same quantity of commodities. The gold thus relieved from the channel of circulation, would, in the hands of individuals, have become capital, the nation deriving all the advantages of its reproduction, with a profit.

The second objection of Lord Liverpool, if well-founded, would certainly render it impolitic in the legislature to enact a seignorage upon the coins constituting the principal measure of property, either as a present or primary principle in the government of the mint. "The merchants of foreign nations, who may have any commercial intercourse with this country, estimate the value of our coins only according to the intrinsic value of the metal that is in them; so that the British merchant would, in such case, be forced to pay in his exchanges, a compensation for any defect which might be in these coins; and he must necessarily either raise the price of all merchandise and manufactures sold to foreign nations in proportion, or submit to this loss."

If the imposition of a seignorage had no effect in augmenting the value of the coins, Lord Liverpool's objection would be correct; but we have already stated, that the coins acquire a value proportionate to the expence of the coinage; the natural limit of a seignorage where the laws cannot prevent illegal additions to the amount of the currency. If so, the relation between the foreign and British merchant would in no degree be changed; they would continue to buy and sell, with the same advantages as before the seignorage was imposed:—there would, it is true, be some differences in price, but not to affect the relative interests of the parties. For example, if a seignorage of $1\frac{1}{2}$ *per cent.* was imposed upon the currency of England, while that of Hamburgh remained without alteration, it will be evident, from what has already been stated, that a fall in the price of British commodities would take place in consequence; but this fall in prices would not be confined to British commodities alone; the foreign commodities brought to the English market must necessarily undergo the same reduction; but the foreign merchant would not be subject to any loss in consequence of this fall in the price of his commodities; for the reduction in the price of English goods enables him to buy as much cheaper as will compensate for the diminution in the price of his foreign wares: neither would the British merchant be subject to any loss by the fall in prices, he being enabled to buy foreign commodities so much cheaper as to compensate for the reduction in the price of English commodities.

The exchanges with foreign nations would be regulated by the same principle. A merchant in London, for example, wanting to remit L. 100 to his correspondent in Hamburgh, to discharge a debt which he owed there, would with his L. 100 of English currency, augmented of $1\frac{1}{2}$ *per cent.* in value by a seignorage, buy upon the London Exchange a bill upon Hamburgh, entitling him to a quantity of Hamburgh currency equal in value to L. 101, 10s.—thus would bills upon Hamburgh be said in the London market to be at a discount $1\frac{1}{2}$ *per cent.* But England would not gain by this discount upon Hamburgh bills; for, let us suppose that a merchant in Hamburgh wishes to discharge a debt in London of L. 100, all bills on London, sold in Hamburgh, will, upon the same principle, be sold at a premium equal to the increased value of the currency in England, to which these bills entitle the holders of them.

As a nation cannot permanently import to a greater amount than it exports, the holders of bills in London upon Hamburgh, cannot permanently exceed the holders of the bills in Hamburgh upon London, so that the discount on Hamburgh bills in the one case, and the premium on London bills in the other, will necessarily balance each other; so that neither party, if we are correct in our argument, would lose or gain, as far as related to the exchange by the imposition of a seignorage upon the British currency.

The third objection of Lord Liverpool to a seignorage upon the gold currency of England is, "That no such charge of fabrication has taken place at the British mint for nearly a century and a half past; and, if it were now to be taken, the weight of the new gold coins must be diminished to pay for this fabrication."

It does not necessarily follow, that a charge for the fabrication of our gold coins should diminish their weight to pay for such fabrication. If the expence of coining L. 100 of gold currency at the Royal Mint was L. 1, 10s., the individual bringing the bullion to the mint, having this charge to defray, would not sell his L. 100 in coin for its weight in bullion; the value of the coin being augmented by the value of the workmanship, he would readily command a quantity of gold bullion more than its weight by the expence of the coinage, or $1\frac{1}{2}$ *per cent.*, as has been already stated. This mode would render any change in the weight of the coin unnecessary.

Lord Liverpool's last objection is, "That these new gold coins would either differ in weight from those now in currency, or, to prevent this evil, the whole of our present gold coins must be taken out of circulation, brought to the mint, and be recoined."

If we are correct in our answer to his Lordship's third objection, the last one will necessarily fall to the ground. All the advantages of a seignorage may be obtained, without such seignorage being deducted from the weight of the coins.

From the arguments we have adduced, we should be justified, we apprehend, in approving of the principle of a seignorage, even upon the coins which constitute the principal measure of property, provided it did not exceed the mere expence of the coinage of such coins; for where a seignorage is charged, there is a tendency, as we have already

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noticed, to a fluctuation in the value of that currency,—an evil which should be avoided as much as possible. Where an extensive paper currency is used, as in England, this evil is considerably increased, even though the issuers of it are liable to pay it in specie on the demand of the holders; still both their notes and the coin might be depreciated to the full extent of the seignorage, before the check which limits the circulation of paper could operate. If the seignorage on our gold coin were 5 *per cent.*, for example, the currency, by an abundant issue of bank-notes, might be really depreciated 5 *per cent.* before it would be the interest of the holders to demand coin for the purpose of melting it into bullion,—the legal check to restore it to its proper value. If the seignorage amounted only to the mere expence of coinage, which is about 10s. *per cent.*, that would be the whole fluctuation in the value of our legal currency, even though bank-notes, payable on demand, formed the most considerable portion of it.

When Charles II. annulled the law for charging a seignorage upon our coins, he must have caused that alteration in the value of property which we here state as the *reason* why we cannot recur to it again, consistently with our national honour. And the late act respecting coinage, which allows a seignorage to be charged upon silver of 4d. *per* oz., but which directs that no charge whatever should be made on gold, it being the standard of property, is therefore a wise measure; as it preserves the integrity of that standard which has existed for upwards of a century, and by which the value of all property has been regulated.

If a seignorage, therefore, is ever charged, it should be from the first introduction of coined money in a state, and ought never to fluctuate in amount, as was anciently the case in this country; because such fluctuations must cause as frequent fluctuations in the value of property, an evil which cannot be too carefully avoided.

Improvements in the Machinery during the Reign of Charles II.

The next important event in the history of the mint, was the introduction of the mill and screw, which took place soon after the restoration of Charles II. Previous to his reign, the money in circulation was made by forging or hammering slips of gold and silver to the proper degree of thickness, then cutting a square from the slip, which was afterwards rounded and adjusted to the weight of the money to be made; the blank pieces of money were then placed between two dies, containing the design of the coin, and the upper one was struck with a hammer. This money was necessarily imperfect, from the difficulty of placing the two dies exactly over each other when the blank piece was between them, as well as from the improbability of a man being able to strike a blow with such force as to make all parts of the impression equally perfect.

The mill or press was first introduced from France into this country in the reign of Queen Elizabeth, but after a few years use was abandoned, as too expensive, and the hammer coinage resumed.

The coining press or mill is of French origin, and is generally ascribed to Antoine Brucher, an engraver, who in 1553 first tried it in the French King's (Henry II.) palace at Paris, for the coining of counters. It continued in use till 1585, in the reign of Henry III., when it was laid aside, on account of its being also more expensive than the hammer coinage. The machine remained in disuse until 1623, when Briot, a French artist, who was unable to persuade the French government to adopt it again, came to England, where it was immediately put in practice under Briot's direction, who was appointed chief engraver of the mint.

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Like many other new inventions, it was sometimes used, then laid aside, and the hammer resumed for about 40 years. In the year 1662, the mill and screw were completely established in the English mint, as it had been by the French in the year 1645. The great improvement which took place in the form and impression of the coins struck by this new invention, gave them a decided superiority over the hammer money; and the excellent and truly philosophical improvements of the late Mr Boulton, which we shall hereafter describe, have placed the process of coining upon a basis so firm, and so decidedly superior, both in facility and economy, that we have no fear of returning to the ancient and less perfect mode of fabricating our money.

Recoinage of Silver in King William's Reign.

The next important feature in the history of our mint, was the extensive silver recoinage of King William, which amounted to upwards of L.7,000,000 Sterling. It was executed at several country mints, besides the mint in the Tower of London. The principle upon which this recoinage was executed, was a subject of great controversy, and occupied the talents of Mr Locke, Mr Lowndes, and others. Mr Lowndes wished to execute the coinage at a rate *per* oz. conformable to the market price of silver; overlooking, at the same time, that the market price exceeding its mint price, arose from the deficiency in the weight of those coins by which silver, as well as all other commodities, was bought and sold. Mr Locke, with that acuteness for which he was so justly esteemed, contended that, if 5s. 2d. of the coin weighed an oz. that would necessarily be the market price of silver; and that its high price arose from 6s. 4d. of the then currency containing no more than an oz. of standard silver. Consequently, if the coinage was executed at a rate higher than the standard of the 46th of Elizabeth, or 5s. 2d. *per* oz. it would be done at the expence of that justice and integrity between the government and the people, which no government would sanction that regarded the rights of personal property. Mr Locke's arguments were so decidedly just, and so convincing, that the government carried the whole nation with them in the measure, though it was heavily felt, owing to the exhausted state of the country, after the long and expensive war it had been involved in.

Controversies occasioned by this Recoinage.

In the course of a little time after the recoinage was completed, Mr Locke's reasoning was called in question, from the circumstance of the price of silver exceeding its mint price, and the consequent disappearance of the coinage, by melting the coins into ingots for sale at the high market price. As this is an exceedingly curious and interesting portion of the history of our mint affairs, we may be allowed to

state a few facts by way of vindicating the accuracy of Mr Locke's theory, and to point out the real cause why its application to practice failed, as it is generally acknowledged that it did; the greater portion of the silver recoinage having, before the year 1717, disappeared from the circulation.

By an *Abstract Account* of the prices which the Bank of England paid for gold and silver bullion in each year, from 1697 to 1811, it appears, that, as early as 1710, they paid L. 4 *per* oz. for standard gold, and 5s. 3d. for standard silver; and, it is probable, that the same price existed at a more early date after the recoinage, though the accounts state no price before 1710. This account we conceive of very great importance, and, we think, will satisfactorily explain why Mr Locke's theory did not permanently produce the effect which the legislature expected from it.

By a reference to the prices paid for gold by the Bank of England from 1710 to 1717, it appears, that the average price *per* oz. was L. 3, 19s. 11d. During this period, the guinea was current for 21s. 6d., at which rate the oz. of gold was coined into L. 3, 19s. $8\frac{3}{4}$d.; for, if one guinea or 5 dwts. $9\frac{3}{8}\frac{9}{9}$ grs. be worth 21s. 6d., 480 grs. or 1 oz. will be worth L. 3, 19s. $8\frac{3}{4}$d. It would appear, then, that the market price of gold was only $2\frac{1}{4}$d. above its mint price; and some debasement by wear may have existed upon the gold currency at this period, causing such excess of the mint price.

While the mint, therefore, coined gold at the rate of L. 3, 19s. $8\frac{3}{4}$d *per* oz., and silver at 5s. 2d., the relative proportion was as 15.43 to 1. There is only one quotation of silver given for the period in question, and it is 5s. 3d. *per* oz. If we take this as the average price for the seven years in question (and we may be justified in doing so by the market prices which follow in 1718 and subsequent years, as extracted from Castaign's *Papers*, and laid before the House of Commons, and ordered to be printed 4th March 1811), at 5s. 3d *per* oz., the average proportion of gold and silver in the market would be 15.22 to 1. But no individual would carry 15.22 ozs. of silver to the mint to be coined into about L. 3, 18s. 7d. when these 15.22 of silver would procure an ounce of standard gold in the market, which could be coined into L. 3, 19s. $8\frac{3}{4}$d. making thereby a profit of about L. 1, 7s. 6d. *per cent*. While this profit continued, it may reasonably be inferred that gold, and not silver, would be the standard of our money.

It was in September 1717, that Sir Isaac Newton delivered in his *Report* to the Lords of the Treasury, giving it as his opinion, that gold was considerably overrated in the mint with respect to silver; and, in consequence of this report, the guinea was, by proclamation, dated 22d December 1717, declared current at 21s. It is of importance to observe the effect produced upon the price of gold by this proclamation; and we are of opinion it will completely prove, that the silver currency had not operated as the standard of value during the period in question. When the guinea became a legal tender at 21s., the price of gold became fixed at L. 3, 17s. $10\frac{1}{2}$d. *per* oz. at the mint; for, if 5 dwts. $9\frac{3}{8}\frac{9}{9}$ grs. be worth 21s., 480 grs. or 1 oz. will be worth L. 3, 17s. $10\frac{1}{2}$d. This fall in the price of gold from L. 3, 19s. $8\frac{3}{4}$d. is 1s. $10\frac{1}{4}$d. *per* oz., and is equal to about L. 2, 6s. *per cent*. It appears by the abstract of prices paid for bullion by the Bank of England, that in 1718 and subsequent years they paid L. 3, 18s. *per* oz. for standard gold, which is a fall from L. 3, 19s. $8\frac{3}{4}$d. of 1s. $8\frac{3}{4}$d. *per* oz.; and if an allowance is made for the debasement by wear, existing at this period upon the gold coin, the fall in the market price of gold will be equal to the reduction in the value of the guinea. But this effect could not have been produced unless gold at the period in question had been the measure of value, and, as such, the measure of its own price.

From these facts, we think the conclusion may be justified, that from 1710, and probably a more early period after the recoinage, to the date of Sir I. Newton's report, the gold money of this country was the standard measure of property; and that the reduction of the value of the guinea, thereby making the relative proportion of gold and silver approximate nearer to those of the market, was the first step of which we have an authentic record, taken by Government to maintain the principles of Mr Locke's theory: and as the avowed intention of this report was to give that rise in value to the silver coin which would protect it from the melting pot, and which could be done by lowering that of gold, it may be inferred, that the legislature were aware that the gold coin had attained the prerogative of being the standard of value at this time. Though the recommendation in Sir I. Newton's report was carried into effect, by making the guinea current at 21s., yet it did not restore silver to its function as the standard of our money; and this, because the current value was not made still lower. Sir I. Newton seemed aware of this himself, and recommended that 10d. or 12d. should be taken from the guinea instead of 6d. This however was not done; and, as the rate of 21s. to the guinea, the proportion of standard gold to standard silver, at the mint, was as 15.07 to 1, the proportion of the market, as we find by the prices of gold and silver at this period in Castaign's *Papers*, was about $14\frac{1}{2}$d. to 1; which constitutes a difference of about 3 *per cent*., gold being still thus much rated above its value to silver; and consequently, not only was no silver coined, but the good and heavy coins were still melted for the high price they brought in the state of bullion. It is surprising that the Government, having seen the operation of the principle recommended in the report of Sir I. Newton, did not carry it a little further, and bring the current value of the guinea to a par with the market proportion of the two metals, and so render it the interest of the public to carry silver to the mint to be coined.

Before concluding our observations upon this highly interesting subject, we must remark, that the great Mr Locke himself did not impute the high price of silver, after the recoinage, to the cause to which we have here assigned it. He attributed it to the permission of exporting silver bullion, and to the prohibition of exporting silver coin. This permission, he said, rendered the demand for silver bullion greater than the demand for silver coin. Dr Adam Smith remarks upon this opinion, that the number of

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people who want silver coin for the common uses of buying and selling at home, is surely much greater than that of those who want silver bullion, either for the use of exportation, or any other use. There subsists at present a like permission of exporting gold bullion, and a like prohibition of exporting gold coin; and yet the price of gold bullion has fallen below the mint price. But in the English coin, silver was then, in the same manner as now, underrated in proportion to gold; and the gold coin (which at that time was not supposed to require any reformation) regulated then, as well as now, the real value of the whole coin.

No other legislative measure having been taken than what we have mentioned, founded upon the *Report* of Sir I. Newton, and the market proportion of gold to silver having seldom rendered it the interest of the public to coin silver; this accounts satisfactorily for the degraded state of our silver currency for the last century.

Recoinage of Gold in 1774.

In the year 1774 and subsequent years, we had a general recoinage of our gold currency, which forms the next prominent feature of our mint history. The avowed object of this recoinage was a reformation of the light and defective coins then in circulation; and the motive for doing so was to prevent the new and heavy coins from being selected from the circulation, and melted for the high price which the gold brought in the state of bullion. In fact, L. 4 of the gold coin then in circulation would not weigh more than an ounce; and, by reference to the prices paid by the bank for gold, we find that this was the market price. The holders of bank notes demanding new and heavy coins for them, required the bank to have a large coinage of gold annually, to supply this demand. These coins were melted, and sold in the state of bullion to the bank for the high price of L. 4 *per* oz. To remedy this inconvenience, the recoinage was completed. And it had the effect desired; for the price of gold, for upwards of twenty years, never exceeded, but was rather under its mint price.

Political economists have disagreed as to the cause of the high price of gold previous to the recoinage. Dr Smith says, "By issuing too great a quantity of paper, of which the excess was continually returning, in order to be exchanged for gold and silver, the Bank of England was for many years together obliged to coin gold to the extent of between eight hundred thousand and a million a year; or, at an average, about eight hundred and fifty thousand pounds. For this great coinage the bank, in consequence of the worn and degraded state into which the gold coin had fallen a few years ago, was obliged frequently to purchase bullion at the high price of L. 4 *per* oz., which it soon after issued in coin at L. 3, 17s. 10½d. an oz.; losing in this manner between 2½ and 3 *per cent.* upon the coinage of so very large a sum. Though the bank, therefore, paid no seignorage, though the Government was properly at the expence of the coinage, this liberality of Government did not prevent altogether the expence of the bank."

Mr Ricardo very justly remarks upon this passage, that, "on the principle above stated, it appears most clear, that, by not reissuing the paper thus brought in, the value of the whole currency, of the degraded as well as the new gold coin, would have been raised; when all demands on the bank would have ceased;" or, in other words, the price of gold would have fallen to its mint price.

Mr Buchanan is not of this opinion; for he says, "that the great expence to which the bank was at this time exposed was occasioned, not, as Dr Smith seems to imagine, by any imprudent issue of paper, but by the debased state of the currency, and the consequent high price of bullion. The bank, it will be observed, having no other way of procuring guineas but by sending bullion to the mint to be coined, was always forced to issue new coined guineas in exchange for its returned notes; and when the currency was generally deficient in weight, and the price of bullion high in proportion, it became profitable to draw these heavy guineas from the bank in exchange for its paper; to convert them into bullion, and to sell them with a profit for bank paper, to be again returned to the bank for a new supply of guineas, which were again melted and sold. To this drain of specie the bank must always be exposed while the currency is deficient in weight, as both an easy and a certain profit then arises from the constant interchange of paper for specie. It may be remarked, however, that to whatever inconvenience and expence the bank was then exposed by the drain of its specie, it never was imagined necessary to rescind the obligation to pay money for notes."

Mr Ricardo remarks upon this passage, that "Mr Buchanan evidently thinks that the whole currency must necessarily be brought down to the level of the value of the debased pieces; but surely by a diminution of the quantity of the currency, the whole that remains can be elevated to the value of the best pieces." With this opinion of Mr Ricardo we cordially agree, and it is upon this principle that a seignorage can be laid upon coinage, without any one directly paying for it as a tax. By restricting the quantity of a currency, this seignorage may be 10, 20, or even 50 *per cent.*, and the price of gold neither raised above its mint price, nor the bank subjected to a run for guineas.

New Constitution of the Mint.

During the period of these important transactions, the constitution of the mint remained without alteration. It had not, however, escaped the attention of the legislature, for we find that, on the 7th February 1798, his Majesty, by an order in Council, was pleased to appoint a Committee of his Privy-Council "to take into consideration the state of the coins of this kingdom, and the present establishment and constitution of his Majesty's mint." The first effort of this committee was to advise the erection of a new mint, with improved machinery, which desirable object was accomplished between the years 1805 and 1810: And in March 1815, a new constitution was introduced, founded upon a very valuable *Report*, drawn up and presented to this Committee by the Right Honourable W. Wellesley Pole, who had been appointed Master of the Mint in the preceding year.

We cannot better explain the whole constitution

and bearings of the establishment, than by detailing the rules, regulations, and instructions, applicable to the duties of the different departments.

The proper duties of the Deputy-Master and Worker are,

To receive, on account of the master and worker, his Majesty's own bullion of gold and silver, as well as the bullion of any other person, brought to the mint for coinage:

To give acknowledgments for the same, specifying the number of ingots, or parcels of coin, according to the purport of any invoice or bill delivered therewith:

To see the ingots safely deposited in the care and joint custody of himself and the master's assayer, for the purpose of being assayed previous to their importation into the office of receipt:

To cause the ingots, when duly assayed, to be brought into the office of receipt without delay, there to be weighed in the presence of the importers and cheque officers:

To make out a mint bill, to be delivered to the importer, testifying the weight, fineness, and value of the several ingots, &c. together with the day and order of the delivery into the mint, and to sign a receipt annexed to the said bill, witnessed by the Comptroller and King's clerk:

To give directions to the master's *first* clerk, for the combining or potting the ingots for the melting, with the proper portion of alloy; and to see that the same be duly entered by the said *first* clerk and melter, in the pot book, and the said book examined by the Comptroller and King's clerk; and to deliver out of the strong-hold such ingots and bullion as are potted, and charge the melter therewith, according to the standard weight of each pot:

To keep an account of the bars received from the melting-house, and delivered to the moneyers, and also of the scissell returned by the moneyers to the melter, for which their respective receipts will be given and entered in the pot-book, that they may be charged therewith:

To receive the coined monies from the moneyers, after the same have been duly tried at the pix by the King's assayer, Comptroller and King's clerk; and to deliver the same to the importer, receiving back at the same time the mint bill which had been given; or if the same be not cleared off, to require that such portion thereof as has been delivered, be indorsed on the bill by the parties, by a receipt, till the whole be discharged:

To seal and lock up in the usual chest, in conjunction with the King's assayer and comptroller, the pieces reserved for the public trial of the pix, and to make good to the parties the pieces so taken, by payment in their sterling value; charging the same to the public expence:

As first executive officer of the mint, to watch over every branch of the department, and to inspect and oversee, as much as lies in his power, the meltings, assayings, and all the different processes of the coinage, and to report to the master on the conduct of the officers:

To draw and indite all letters, instructions, commissions, and other writings agreed upon and ordered by the master and worker, for the service of the office, and to have the same recorded by the clerk of the papers:

To receive all monies issued at the exchequer or elsewhere, for the service of the mint; and to keep the public account of the master, to be laid annually before the auditors of public accounts, with the proper vouchers, the said account to be signed and attested by the master himself:

To make quarter books of the salaries, wages, allowances, &c. due to the several officers, clerks, artificers, and others belonging to the establishment; and to make payment thereof on the quarter days, namely the 5th of January, the 5th of April, the 5th of July, and 10th of October, whenever there shall be funds for that purpose: Also, to pay the moneyers and melters charges for coinage, according to the rates set forth in their respective agreements with the master; the same to be payable out of the monies issued for the service of the mint, the salaries, &c. being previously discharged: Also, to pay the incidental expences and disbursements usually incurred in the different offices; and to pay the solicitor his account for disbursements in carrying on prosecutions for offences against the laws relating to the coin, out of such monies as shall be impressed from time to time, for that service, exclusive of the ordinary allowance:

To receive all the fees arising to the master's office under the indenture or otherwise, and to apply the said fees to the payment of the master's salary, in the manner directed by the act 39th Geo. III. and to account for the same to the Lords Commissioners of his Majesty's Treasury, by half-yearly statements, showing the deficiency of the fees, and the sum to be provided, or the excess, as may happen; and to make out a yearly account to the Treasury:

For this office he is to give the usual security, or such other as may be required by the Lords of the Treasury:

In conjunction with the comptroller, to inspect and examine the accounts of the clerk of the irons, as to the dies supplied to the engraver and moneyers, and the faulty ones destroyed:

To attend the duties prescribed by the act 14th Geo. III. respecting the standard money weights.

The proper duties of the King's Assayer are,

To keep a book of the assays made by him, of all such gold and silver as may be brought into the mint, whereby the quantity and fineness may appear:

If the master of the mint, or the merchant, or importer, who brings his gold or silver for coinage, may not accord between them of the true value of the bullion, or if it be not malleable and fit for working, or sufficiently nigh to the standard, according to the customs of the mint, the King's assayer is to try the truth in that part, in the presence of the master and comptroller, and the master shall receive the same in manner as it becometh:

To report (after the bullion has been weighed, potted, and melted) the assay of every several pot, commonly called the pot assay, which pot assay

shall be made of some bar of the said bullion, to be taken by the comptroller, the King's assayer, or surveyor of meltings, or any one of them, after the pot is cast out; the said report to be made in writing, and delivered through the office to the surveyor of meltings:

To take care that the bars of gold and silver be melted, and the monies made agreeably in fineness, to the indented trial plates, made by direction, and ordered to be used by the royal authority; whereof one trial plate for the gold, and one for the silver, shall remain with the King's assayer:

In conjunction with the other principal officers to oversee and survey the assaying, and melting, and making the monies, at all times and in all places; and endeavour and procure that the said monies, and every of them, shall be properly made and perfected:

To see and procure, with the comptroller, and weigher, and teller, that the balances and weights be put to point from time to time, when they shall need it; so that no default be found in them, to the hurt of his Majesty and his people:

To make proof (by a process called the pixing) of the monies before their deliverance to the bringers in of the bullion; the said proof to be made in the presence of the master and worker, comptroller, and King's clerk, by an assay to be taken of the fineness as well as of the weight, by such quantity, and after such sort as shall be agreed on, or as has been customary, namely, by weighing the pound weight in tale; and taking one piece out of every journey weight of gold and silver respectively for the assay of the fineness, as directed by the mint regulations. To report thereon, and the report to be entered in the pix books:

In conjunction with the master, and worker, and comptroller, to see a portion, namely, one piece out of every journey weight of the said monies (after they have been proved to be good), ensealed in a packet, and put into a box (called the pix-box), to be locked up under the separate keys of the said officers, there to remain until trial thereof by jury (called the trial of the pix) shall be made before the King, or such of his council as are usually appointed at Westminster, or elsewhere, for that purpose:

He shall be bound to instruct in the art of assaying, the probationer assayer, who shall be nominated by the King's assayer, and approved by the master and worker:

To attend the duties prescribed by act 14th Geo. III. respecting the standard money weights.

The proper duties of the Comptroller are,

To enter on record in a journal or ledger, all such bullion of gold and silver as shall, from time to time, be brought into the mint, which entry shall comprehend the weight as declared by the weigher and teller; the fineness as reported by the master's assayer; and the value of the said bullion, the parties names that brought it, and what day:

To deposit at the office of receipt in the strong-hold, of which he shall possess a key (in conjunction with the deputy-master and worker, and King's clerk), the bullion, after it shall have been received, and the assays and weight thereof made, reported, and entered, there to remain until it is required to be delivered by the deputy-master for the meltings:

In conjunction with the King's clerk, to take an account of the ingots delivered by the deputy-master out of the strong-hold for the meltings, according to the entry made by the master's first clerk and melter in the pot-book, and to examine the said book as to the calculations of the quantities and fineness, of all manner of gold and silver and alloy, combined and put to each pot respectively for the meltings, and to subscribe the same with his initials:

To take also an account and oversee the weighings of the bars and scissell, passed through the office between the melter and moneyers; for which their respective receipts shall be entered in the pot-book:

To keep an account of all the deliveries of the monies, and to ascertain, at the end of every month or oftener, the balances due by the master to the several importers, and also the balances in the hands of the moneyers and melter, and agree the same with the deputy-master, who is to charge the said moneyers and melter therewith accordingly:

In conjunction with the other principal officers, to oversee the melting, rolling, sizing, and making, the monies, at all times and in all places; and endeavour and procure that the said monies and every of them shall be properly made and perfected:

To see and procure, with the King's assayer, and weigher, and teller, that the balances and weights shall be put to point from time to time when they shall need it, so that do default be found to the hurt of his Majesty or his people:

To attend the proof and trial (called pixing) of the monies before their deliverance to the importer, and to try the weight of some of the pieces in each journey weight singly, as a check that there may be no great variation from the true weight; and also to retain two pieces from each journey weight, one to be delivered to the King's assayer for his assay, and the other to be locked in the pix-box, to be tried before the King or his council;—to docquet the parcel containing the pieces for the pix, and with the other officers enseal the same, and lock it in the pix-box:

To deliver upon oath, before one of the Barons of Exchequer, a roll, which shall be called a Comptroller's Roll, containing an account of all the gold and silver monies coined monthly in the said mint:

In conjunction with the deputy-master to inspect and examine the accounts of the clerk of the irons, as to the dies supplied to the engraver and moneyers, and that the faulty ones be destroyed:

To attend the duties prescribed by act 14th Geo. III. respecting the standard money-weights.

The proper duties of the Superintendent of Machinery and Clerk of the Irons are,

To inspect, from time to time, the several steam-engines and boilers, and the machinery, apparatus, and implements, used in the coinage, and to see that the same are kept in proper order for immediate working, at all times:

To oversee and direct, in conjunction with the

company of moneyers, the artificers and workmen employed by Government about the machinery, in doing all manner of work that may be expedient; and likewise in the construction of all the smaller implements and tools necessary to carry on the coinage, upon the principle of the machinery erected; the repairs and work being ordered under the authority of the master and board of mint officers:

To superintend the working of the machinery, and instruct (to the best of his ability) the officers and moneyers in the use and management of it; and to report to the board upon any neglect or misuse:

To examine the several accounts of expences incurred in the machinery,—certifying, in pursuance of the agreements entered into between the master and the moneyers, the charges, both in respect to the bills, and also the wages to the artificers, which shall respectively be borne both by the Government and the moneyers.

As Clerk of the Irons,

To superintend the die press-rooms, and purchase, or procure to be forged, at the cheapest rate, to be approved by the board, all such dies as shall be ordered by the board, and to take care that the same are of the best quality, and properly forged:

To oversee the workmen in the die press-room, and that the dies be skilfully sunk and hardened, and properly turned; and to attend to all matters and things for the well ordering and conducting this service:

To keep a true account of all the blank dies, matrixes, and puncheons, for coinage, which shall be delivered to the engravers, or that shall be sunk or stamped by the engravers, and after stamping made fit for use and hardened:

To require the engravers, monthly, to return as many dies as shall be found faulty and worn:

To give an account, as often as required, to the master and comptroller, of the blank dies delivered to the engravers, and the faulty ones returned, that a just account may be kept, and all the faulty dies defaced:

To unlock, and be present, whenever the great die-press for multiplying the dies is used; to be responsible for its not being applied for improper purposes; and that no medals, pattern-pieces, or coin of any description be struck, but by a written order from the master or his deputy.

The proper duties of the King's Clerk, and Clerk of the Papers, are,

To attend the weighings in, and enter in his ledger-book an account of all such bullion of gold and silver, as shall be brought into the mint, describing the weight and fineness as reported, the parties names that brought it, and the day:

To deposit at the office of receipt in the strong-hold, of which he shall possess a key in conjunction with the deputy-master and comptroller, the bullion, after it shall have been weighed in, and the weight and assays reported; there to remain until it shall be required to be delivered over by the deputy-master for the meltings:

In conjunction with the comptroller, to take an account of the ingots delivered by the deputy-master to the melter, as set down in the pot-book, and to examine the calculations of the pot-book as to the quantities and fineness of all manner of gold, and silver, and alloy, put to each pot, and to subscribe the same with his initials:

Also to take an account and oversee the weighing of the bars and scissell passed through the office between the melter and moneyers, for which their respective receipts shall be entered in the pot-book:

To attend the pix and deliverance of the monies, and record the same, and agree the master's, melter's, and moneyer's balances, up to the end of every month:

To enter (as clerk of the papers) in the record-book, all office-letters, papers, appointments, warrants, and proceedings of the board:

To assist the deputy-master in the secretary department, and instruct the master's second clerk in the keeping the proper entries of bills and accounts for expences incurred, or in making copies of all such papers as shall be required by the master or his deputy, or by the board.

General Instructions for the common duties of the Principal Officers (before-mentioned), to be by them observed.

To make their ordinary habitations and abode in the houses assigned them within the mint:

To meet in the board-room at the mint office every Wednesday (after the delivery of the monies), or on such other day and hour as the master, or the service of the mint, shall require, there to form a board. Three members (the master or his deputy being one) are competent to act:

To consult together, and order all business appertaining to them concerning the office, determining the hours of attendance of the several officers, the receipts of the bullion, and the delivery of coin:

To consider and give directions to the solicitor of the mint, from information laid by him before the board, for undertaking prosecutions for offences relating to the coin, and require him to report, from time to time, as to the state of the prosecutions and convictions:

To take up and employ such smiths, workmen, and labourers as may be severally wanted in the die department and assay offices; and for assisting in the porterage and weighing of the bullion and coin in the office of receipt, and to order the superintendent of machinery and clerk of the irons, to purchase or procure to be forged, all such dies as are necessary for the coinage or service of the mint, and to provide all necessaries, and do all manner of business within the mint, as may be needful:

To observe, follow, and perform, all orders, warrants, or significations of the master and worker, whether grounded upon warrants from the King, the Lords of the Committee of Council for coin, or the Lords Commissioners of the Treasury; and in all things to obey jointly or severally, in their respective places, such directions as he shall from time to time judge necessary and fit to give for the service of the mint:

To see that the accounts of the office for the receipt of the bullion and delivery of the coin, as well as the check and control thereof, be kept in due manner, as prescribed, and that the comptrolment roll of the monies, coined monthly, be exhibited yearly to the auditors of public accounts:

To see also that the receipts and payments of all monies for the service of the mint, be charged and accounted for in the master's public account, and that all bills, accounts, and statements, belonging thereto, be examined and allowed under at least three signatures of the principal officers, of which the master's deputy is to be one, previously to its being laid before the audit office:

Also to examine and report to the Lords Commissioners of the Treasury on the fees derived to the master's office; and the application thereof, pursuant to the act 39th Geo. III. as stated in the receiver's account; in order that the same may be declared and passed:

To prescribe to the under officers and servants, their several charges and duties, and to see the due performance of them, and in case of negligence or unfaithful conduct, to report to the master; or, as far as the board are authorized, remove them from their situations:

Not to suffer the works of the mint to be viewed without an order signed by the master; or any stranger or foreigner, not having business at the mint, without knowledge of his quality, to have intercourse with the officers while performing their duties.

The proper duties of the Master's Assayer are,

To receive from the master and worker all manner of gold and silver ingots brought to the mint:

To deposit the same in the joint custody of the deputy-master and himself, in the strong-hold of the assay office, till the assays are made:

To cut one or more pieces from each ingot (as he may think proper), and assay the same:

To make written reports of the assay of each ingot, describing the fineness, date, and name or mark of the importer, and keep a record thereof. To make also such remarks on the quality of the bullion as may be needful for the master's information, and to deliver the list usually given by the importer, of the purchase assays:

To give instructions for the classing of certain of the ingots together, so that the bullion may be mixed and worked as close to the standard as possible, and advantages procured by the mint assay:

To deliver the ingot when assayed into the office of receipt:

The proper duties of the Master's First Clerk and Melter are,

To superintend and carry on the operations of the meltings and refinings, according to agreements (stating the prices and conditions) to be made from time to time between the master and melter:

To attend the weighings in at the office, and rate and standard the ingots in conjunction with the other officers; and their several accounts agreeing, to enter the same in his journal; so that no difference may arise between the deputy-master and himself as to the value of the bullion to be delivered to melt:

To arrange under the direction of the deputy-master from the said journal, and from the list of ingots classed by the master's assayer, the combination of the bullion for melting, and to make the proper calculations of the quantities and fineness of all manner of gold and silver and alloy put to each respective pot, and to enter the same fairly in a book (called the pot-book), and subscribe his initials to each pot so made up:

To receive the bullion so prepared from the deputy-master, to be deposited and melted under the joint custody and inspection of himself and the surveyor of meltings:

To melt and cast the bars (according to agreement), and, after they have been assayed and reported standard by the King's assayer, to deliver them into the office of receipt; there to be weighed by the weigher and teller, in presence of a cheque officer, and passed to the moneyers:

To receive the returns of scissell, light work, and ends (according to agreement), from the moneyers, to be weighed in like manner, the receipts between the moneyers and melter for the bar and scissell being entered in the pot-book:

To receive from the deputy-master all such gold and silver as may be necessary to refine; to make up an account in the pot-book of each charge, showing the standard amount, to be signed with his initials, and examined by the comptroller and King's clerk; and to supply a quantity of fine ingots, equal in standard weight by computation to the amount delivered to refine, the same to be assayed by the master's assayer, and weighed into the office of receipt, and rated and standarded so as to combine and pot with the coarse ingots:

To agree the balances remaining in his hands with the deputy-master, at the end of each month:

To employ and instruct the master's second clerk in the art of melting bullion; and *lastly*, to be ready to do his work at all times, when he shall be warned by the master and worker; and to attend to his Majesty's service as need shall require, both morning and afternoon, and to work so many hours every day (Sunday excepted) at such tasks as shall be thought fit by the master, and appointed by the board.

The proper duties of the Provost and Company of Moneyers are,

To superintend and carry on jointly as a company the several processes for the manufacture of the coin, in the rolling, annealing, blanching, cutting out, sizing, and stamping, according to agreements (specifying the prices and conditions) to be made, from time to time, between the master and worker, and the provost and company:

To receive the standard bars of gold and silver for making the monies, from the melter at the office of receipt, there to be weighed by the weigher and teller, in the presence of a check officer, and to give receipts for the same, to be entered in the pot-book:

To coin such quantities of the different species of the monies as shall be directed by the master (ac

cording to agreement), and to bring the said monies (in clean pieces) into the office of receipt, in journey weights; there to be tried at the pix and weighed:

To deliver the monies proportionally in weight, according to the bars received; and if any thing lack of the weight at the time of deliverance, to content and pay unto the master the balance at the time of the delivery:

To make out of the bars which shall be delivered to them clean and fit to be wrought, seven twelfth parts into money, so that there be but five parts in twelve scissell:

To return the scissell, light work, and ends to be remelted, proportionally (according to agreement); the same to be delivered into the office of receipt, to be weighed by the weigher and teller, in the presence of a check officer, and to take receipts from the melter, to be entered in the pot-book:

To agree with the deputy-master, the balance remaining in their hands at the end of each month, that they may be charged therewith; and from time to time (as the master shall require) make full payment and deliverance of all manner of monies, with all convenient speed, in order to discharge the said balances, or bring in sufficient supplies of gold and silver, bullion, or ingots, equal in value, according to the weight and assay to be made thereof at the time:

Not to take either singly by the provost, or jointly by the company, any apprentice to be instructed in the art or mystery of a moneyer, or any part thereof, without the licence and permission of the master first had and obtained under his hand in writing:

To oversee, in conjunction with the superintendent of machinery, who is to direct the same, the artificers employed by government about the machinery, in doing all manner of work that may be expedient, and in the construction of the smaller tools and implements for the coinage:

To be ready to do their work at all times without denial, when they shall be warned by the master:

Duly to attend his Majesty's service, in the present way of coining, as need shall require, both morning and afternoon; and to work at such tasks, and so many hours every day (Sunday only excepted), as shall be thought fit by the master, and appointed by the board, according to the labour of their respective tasks, and the length of days:

Neither the provost, nor any of the moneyers, their apprentices or servants, at any time, to vend, pay, or distribute any piece or pieces of the coined monies, until the same shall have been delivered by them, according to the course of the mint, into the office of receipt, and duly assayed and pixed.

The proper duties of the Chief Engraver are,

To make and frame such draughts and embossments, or receive such models for engraving, as the master shall direct:

To engrave from the said designs or models all such matrixes and dies as the master shall direct, and the service of the mint require:

To oversee from time to time the multiplication of the puncheons and dies, in the die press-room, and to receive the dies from the superintendent and clerk of the irons, that they may be delivered to the surveyor of the money presses in a proper state for the use of the coinage:

To return monthly to the superintendent and clerk of the irons, as many dies as shall from time to time be found faulty, and worn by using or otherwise:

Not to work, or make, or grave any puncheons, matrixes, dies, or stamps, for the making or coining of any money, but only in such places in the mint as shall have been assigned thereunto:

To oversee the striking of the monies in the coining press-room, and to direct all such dies as are faulty to be taken out of the press, and fresh dies put in, that the monies may be properly struck.

The proper duties of the Weigher and Teller are,

To weigh at the office of receipt, under the master's direction, all manner of bullion brought to the mint to be coined, or for the service of the King:

To weigh the bullion, according to such weight or draught (near to a journey weight) as has been customary:

All importations to be weighed in the presence of the deputy-master, or master's clerk, comptroller, or King's clerk, and the importer, who is to state the weight of each ingot from his list, for the guidance of the weigher:

To declare the weight aloud from his scale, that the same may be taken down by the officers and importers:

In conjunction with the other officers, to see that the bullion is free from dirt, and in a fit state for weighing, and to do strict justice, as much as in him lies, between the parties:

To weigh the bars and scissell, passed between the moneyers and melters, and declare the weight of each draught; and also all supplies of fine ingots received from the melter; and the balance or supplies of ingots, &c. made from time to time by the moneyers and melter:

To weigh the coined monies from the moneyers to be delivered to the importers in even journey weights, or to declare the plus or minus on each draught, that the same may be recorded, and the moneyers made answerable for the deficiency of weight or balance at the time of deliverance:

To attend the pix, and tell out the number of pieces contained in a pound weight Troy of the respective species of monies to be delivered to the King's assayer for trial:

To undertake by himself, or by a proper workman in the mint (according to an agreement of prices and conditions), to clean and adjust the beams, &c. in the office of receipt, and to keep the same in order, so that they be always ready and perfect for working.

The proper duties of the Surveyor of Meltings are,

To survey the meltings of all gold and silver, and to take care that the ingots or bullion, according to the number and description in the pot-book, with their proper alloy only, to be weighed by himself, be put into the pot they are respectively set out for:

Coinage.

To see that nothing but scissell or such returns of ends as be clean and good, of gold and silver, respectively, be put into the pots of scissell:

During the time the pots are melting not to absent himself, or to be out of view of the pots so melting, until they have been poured off:

To take two or more assay pieces from some bar or portion of each pot cast from the top, middle, or bottom, of the pot, as agreed with the King's assayer:

To fold up each assay-piece in a paper, docqueted with a description of the ingots and alloy, or scissell, &c. melted in each pot, the number of the pot and the date, and to deliver the same to the King's assayer:

To possess a key of the strong-holds in the melting house, and not to suffer any bars of gold or silver to be delivered out of his custody, until such time as they have been duly assayed and reported good, which reports will be made to him in written notices, transmitted through the office by the King's assayer:

To keep a book containing the weight of all gold and silver as shall be molten from time to time, with the alloys put into the same.

The proper duties of the Surveyor of the Money Presses are,

To inspect the coining presses, and to have a distinct and separate lock upon each of the presses:

To be present at the striking of the monies, and not to suffer the presses to be used for striking any pieces or coins but such as the master shall direct:

To have the custody of the dies received from the engraver and clerk of the irons, to give out the same for coinage, and return the faulty ones to the chief engraver, to be delivered to the clerk of the irons:

To polish the dies, or oversee the doing of the same, when the moneyers are coining:

To inspect the monies, that they be well made and free from brokages, and faulty or dirty pieces; and to do, execute, and perform, all such other works and services in the said office as the master shall direct and appoint.

The duties of the Probationer Assayer are,

To receive instructions from the King's assayer for acquiring a knowledge and proficiency in the art of assaying:

To do all such services in carrying on the business of the assay-office, as the King's assayer shall require, and the master direct.

The duties of the Master's Second Clerk are,

To make out fair copies and entries of all such accounts and papers as might be required in the master's office, and to do all such services in the said office, as the master or deputy-master shall direct or appoint:

To receive instructions from the master's first clerk and melter in the art and undertaking of the meltings.

The duties of the Assistant Engraver are,

To assist the chief engraver in the engraving of the reverses, lettering, or such other parts of the dies as the chief engraver shall appoint:

Coinage.

To receive instruction from the chief engraver in the art of engraving, and to render all such services in the department as the chief engraver shall require, and the master direct.

The duties of the Mint or Bullion-Porter are,

To attend the office daily, if required:

To be present at all importations and deliveries at the office:

To mark on the assay paper the weight of each ingot weighed at the scale:

To arrange, with the assistance of the master's porter, the ingots in the strong-hold, and put them together in pots, to be carried down to the melting-house:

To oversee the under porters in giving all proper assistance at all the weighings, and in the receipt into the mint of all bullion, and deliverance of monies or bullion:

To give the regular notices for the attendance of the officers, and other persons at the office, for business, and to do all such services as shall be directed by the master or board.

The proper duties of the Warden of the Mint are,

In conjunction with the master and comptroller, and with the assistance of the King's assayer, to make the weights of a guinea and of a shilling, according to the established standards, and also parts and multiples of the same, to be presented to council, and, if approved, to become standard weights, to be lodged in the mint:

To have the custody of the said weights at the mint, in conjunction with the master and comptroller:

To make also, in conjunction with the master and comptroller, and with the assistance of the King's assayer, copies or duplicates of the said weights, to be lodged with an officer called the stamper of money weights:

To summons once, or oftener, in every year, by warrant under the hands of himself, the master and comptroller; the stamper of money weights to appear before them, and produce the said duplicates of the standard weights, to be examined and compared with the standard weights lodged at the mint office in their custody:

To pay the salary allowed to the stamper of money weights out of monies to be entrusted to him for that service by the master of the mint:

No person to be appointed to act as deputy to the warden, without the sanction of the Lords of the Treasury.

The proper duties of the Stamper of Money Weights are,

To attend the summons of the warden, master, and comptroller, and to have the duplicate weights in his possession compared with the standard weights at the office, at least once a-year:

To adjust the duplicate weights by the said standard weights, that all weights for weighing gold and silver money may be regulated by the said duplicates:

To stamp the weights made use of in weighing

Coinage.

the money, receiving a fee of one penny on every twelve weights stamped or marked pursuant to act of Parliament:

No other weights but those stamped by the stamper of weights, to be accepted by law, for determining the weight of the coins; and persons counterfeiting the stamps, or altering weights so stamped, to be fined and imprisoned:

Not to interfere with the weights of the founders' company, if they have their weights sized and marked as above:

To receive the salary allowed to his office from the warden or his deputy.

The proper duties of the Solicitor of the Mint are,

To attend the board of mint officers every Wednesday, or such other day as may be appointed, to lay before them such information and depositions, in regard to persons offending against the laws relating to coin, and to receive the board's orders for acting thereupon:

To act in conformity to such order, in the prosecution of all such persons as shall clip, counterfeit, melt down, wash, file, or diminish the current coin of the kingdom, or alter any counterfeit coin, knowing the same to be counterfeit, or be guilty of any crime or offence concerning the said coin or money, or against the laws relating to them:

For the better carrying on of the prosecutions that may happen, at the same time, in different counties, to substitute and employ such other person as he shall see fit in his stead:

To make out quarterly accounts of the expences of the prosecutions, with the proper vouchers, to be examined by the board of mint officers, showing the disbursements made by him; and to make an abstract account at the end of every year, of monies received and expended, that the balance may be ascertained and the account discharged.

sual Routine of Business at the Iint.

We shall now proceed to state the regular routine of the business of the mint, when the processes of the coinage are going forward, under the various check-officers whose duties we have enumerated.

old.

The Bank of England are the usual importers of gold bullion. When they bring a parcel of gold for coinage, say, for example, 12 ingots; on their being brought to the mint, they are deposited with the master's assay-master, and under the key of the deputy-master of the mint, where they remain until the assay-master has made an assay of every ingot separately. When he is ready to deliver the assay reports of the said bullion to the master and worker or his deputy, the importers are required to attend in the mint office of receipt, where the said assay reports are read over by the weigher and teller. The same are recorded, according to their numbers, in the journals of the master, comptroller, and master's first clerk. To render this more intelligible to our readers, we shall insert the form of an importation of gold, by way of example, and make the same into pots, for the process of melting, which immediately follows its importation. The letter B is for better, and W for worse, than standard fineness, and the figures on the left hand are the excess of fineness above standard, and those on the right hand, the excess of alloy beyond standard gold.

Coinage.

Saturday, 20th September 1817.

Importation from the Governor and Company of the Bank of England, of 12 Gold Ingots for Coinage.

Rating.	Assay Report.	Weight of Ingot.	Rating.
1 17 12	No. 1 B. 1 *carat grs.*	15	
1 17 0	— 2 1	15	
1 17 12	— 3 1	15	
	— 4 W. 1	15	1 17 12
	— 5 1	15	1 17 12
	— 6 1	15	1 17 12
1 17 12	— 7 B. 1	15	
1 17 12	— 8 1	15	
1 17 12	— 9 1	15	
	— 10 W. 1	15	1 17 12
	— 1 1	15	1 17 12
	— 12 1	15	1 17 12
11 5 0		Gross 180	11 5 0
		Standard 180	

A mint bill is given to the importer for this bullion, testifying the weight, and fineness, and value of the several ingots, together with the day and order of the delivery into the mint. A receipt is annexed to the bill signed by the deputy-master, and witnessed by the comptroller and King's clerk. When the said bullion is delivered to the importers in the state of coin, the mint bill is received back at the same time by the deputy-master and worker.

The first clerk and melter is next required to pot the gold for melting, and the same is recorded in the pot-book as follows:

Saturday, 20th September 1817.

FIRST POT.

Nos.	Bank Eng. 20. Sep.			
1.	————	1 17 12	15 0 0	
2.	————	1 17 12	15 0 0	
3.	————	1 17 12	15 0 0	
4.	————		15 0 0	1 17 12
5.	————		15 0 0	1 17 12
6.	————		15 0 0	1 17 12
		5 12 12	90 0 0	5 12 12

SECOND POT.

Nos.	Bank Eng. 20. Sep.			
7.	————	1 17 12	15 0 0	
8.	————	1 17 12	15 0 0	
9.	————	1 17 12	15 0 0	
10.	————		15 0 0	1 17 12
11.	————		15 0 0	1 17 12
12.	————		15 0 0	1 17 12
		5 12 12	90 0 0	5 12 12

These pots are delivered to the melter, and placed

Coinage. to the debit of his account in the books of the deputy-master, comptroller, and King's clerk.

If the melter does not immediately melt the bullion when delivered to him, it is placed in his strong-hold, to which there are two keys, one of which is kept by himself, the other by the surveyor of the meltings.

When the bullion is to be melted, the surveyor of the meltings is in attendance, and examines that the ingots correspond with the numbers recorded in the pot-book, and, when satisfied that they are correct, the ingots belonging to each pot respectively are charged into the melting-pot, and it is his duty to attend until they are melted and cast into bars, without ever leaving the melting-house.

When the betterness and the worseness of the ingots do not balance each other (as we see it does in the examples above), but when there is an excess of betterness, which requires an addition of alloy, it is calculated after the standard of 22 carats of fine gold, and 2 carats of alloy, being the English standard of gold. The alloy is weighed by the surveyor of the meltings, and put into the melting-pots in his presence. And when there is an excess of worseness, which requires an addition of fine gold to produce the standard of the coin, the same is weighed by the surveyor of the meltings, and put into the melting-pots in his presence.

The gold is melted in pots made of black lead. Those chiefly used in the royal mint are of foreign manufacture; and are less liable to break in annealing than pots of English manufacture, from their having more black lead and less clay in their composition. Before the gold is charged into the pots, the pot is placed in a furnace of 14 inches square, and 20 inches deep from the grate. It is placed on a stand usually cut from the bottom of an old pot, and is about an inch or inch and half thick. This is covered with coke dust, which makes the pot part from it when withdrawn from the furnace, when the metal is melted. To give depth to the pot, a muffle is placed upon it, which is in fact an old pot cut in two, and the wide end fitted to the mouth of the pot. The muffle is covered with the other half of the old pot, so that it is one pot inverted over another. The object of this contrivance is to give an additional depth of 4 inches of fuel above the pot, by which a more equal degree of heat is given to the melted gold, which is an object of great importance, otherwise there might not be an uniform mixture of the alloy and fine gold, which is easily effected at a proper degree of temperature. By removing the top which covers the muffle, the process of the melting can be inspected as required. The furnace is lighted by putting a little ignited charcoal over the grate, and around the melting-pot. About 4 inches of coke is put over the charcoal, leaving the door of the furnace open, and the damper, which communicates with the flue of the furnace, shut. As soon as the coke is properly ignited, the furnace may be filled to the height of the muffle with coke; and leaving the door still open, and the damper shut, the fire will gradually burn through, and not endanger the pot, by being too suddenly heated. When the pot is heated to a bright red, the gold is charged, and generally the pot, weighing from 90 to 105 lbs. Troy, is melted in one hour. When the metal is thoroughly melted, it is well mixed or stirred, with a rod of black lead, which is heated to a bright red before putting it into the metal. The pot is then withdrawn from the furnace, by first drawing a bar of the grate (which is moveable) on each side of the pot, and forcing all the fuel into the ash pit; a pair of tongs is then made to encircle the pot, to which is attached a lever, by which the pot is lifted upon the top of the furnace. The pot is then carried, in another pair of tongs, and its contents poured into two moulds, which produce two bars of 10 inches long, 7 inches wide, and 1 inch thick. The pot is returned to the furnace, the bars that were withdrawn replaced, and the ignited fuel put round the pot, and charged with more gold. A pot, by proper treatment, may be used eight or ten times in the course of a day. Coinage.

From each pot melted, two pieces or samples are cut, one from the first poured bar, the other from the second. These are put in papers, marked accordingly by the surveyor of the meltings, who delivers them wrapt up in a slip of paper, which contains the numbers of the ingots of which the pot was composed, their gross weight, with the quantity of alloy or fine gold, as it may happen, which was added in the melting. The bars of gold, after being weighed by the melter for his own satisfaction, are placed in the strong-hold, under the key of the surveyor of the meltings, until the King's assay-master has reported their standard quality. If they are found to be the proper standard, he sends a written order, authorizing them to be delivered to the moneyers, for the purpose of making coin.

When the bars are delivered to the moneyers for coinage, they are carried by the melter to the office of receipt and delivery; where they are weighed by the weigher and teller, in the presence of one of the check officers, one of the moneyers, and the melter.

The moneyer gives a receipt in the pot-book to the melter for the gold so delivered, and the same is placed to the credit of his account in the books of the deputy-master, comptroller, and King's clerk, The same process is gone through when the moneyers return the portions of the gold, commonly called scissell, which they cannot make into money, and for the weight of which the melter gives a receipt in the pot-book, which is placed to the credit of the moneyers, and debit of the melter's account.

When silver bullion is imported into the mint, it Silver. passes through the same preliminary stages that we have seen the gold pass. The weight of an ingot of silver is from 50 to 60 lbs. Troy; they are numbered, assayed, weighed before the importers, and potted for melting the same as in gold. The only difference is in the pots, weighing from 400 lbs. to 450 Troy lbs. each. The silver is reported in ozs. and dwts.; and the standard computed to that of 11 ozs. 2 dwts. of fine silver, and 18 dwts. alloy. The pots are melted under the inspection and superintendence of the surveyor of the meltings; in every respect the same as the gold, excepting that three

samples are taken for the assay, one from the first, the middle and last poured bar of each pot.

The process of melting silver, now practised at the Royal Mint, is a recent invention, and a very great improvement. The usual mode was to melt it in black lead pots, and a considerable coinage of tokens for the bank of Ireland was performed with the meltings done in this way. The importations being entirely Spanish dollars, and the tokens of that standard, the melter could easily melt them in quantities of 60 lbs. Troy, which was done. The inconvenience of this mode was severely felt, because ingots of silver of various qualities could not be imported for coinage, from the difficulty of not being able to blend several together in one pot, so as to produce the proper standard of our money. So sensible was government of this imperfection in the mint, that, in the year 1777, Mr Alchorne, then master's assay-master, was sent to visit the mints of Paris, Rouen, Lille, and Bruxelles, and to collect information as to the arts of coining practised in those mints, and particularly the art of melting silver in large quantities. Mr Alchorne's intimate knowledge of the English mint, together with his various and extensive knowledge as a practical chemist, well fitted him for the important undertaking; and his observations on the coin and coinage of France and Flanders is exceedingly creditable to his judgment and knowledge.

It is worthy of remark, that it is on record in the books of the mint, that, in the recoinage of King William III. the pots of silver weighed 400 lbs. Troy and upwards; but every trace as to how this quantity of silver was melted is completely lost; and it is only conjectured that it was done in pots made of wrought-iron. But not a vestige of a melting furnace, fitted for such a purpose, is to be found in the Tower, nor a single record of the method practised.

In the year 1758, some trials for melting silver in wrought-iron pots took place, by means of a blast-furnace, but they were found so laborious, inconvenient, and profitless, as to cause the process to be abandoned.

In 1787, when some silver was imported into the mint for coinage, new experiments were made by the late Mr Morrison, then deputy-master and worker, and who conducted the meltings. A blast-furnace was again tried and abandoned. He next attempted to melt the silver in large black lead pots, containing from 100 to 120 lbs. Troy; but the repeated breaking of the pots, although it was attempted to guard them by outside luting, proved a great interruption to the business, and serious loss to the melter. Trial indeed was made with cast-iron pots; but these were found subject to melt, and the iron got mixed with the silver. The work too was continually stopped by the King's assayer, in consequence of the metal not being of the proper standard, it being always refined by the process of melting, and lading it with ladles from the pot.

Independent of these considerations, very great difficulty arose at the office in arranging the potting, previous to the operation. The practice pursued at the mint (in order to reduce the metal to standard), of combining and blending the various ingots of better and inferior qualities, adding what little portion of alloy or fine metal that might be necessary to obtain accuracy, rendered it impossible, where the ingots weighed from 60 to 80 lbs. Troy, to pot them of a weight not exceeding 100 lbs. Troy. It therefore became necessary, in the first place, to reduce the larger description of ingots to a smaller size by melting, and these were again weighed into the office of receipt. Hence a double operation took place, occasioning additional labour, waste, and expence to the melter, and requiring extraordinary trouble and attendance on the part of the office. It was very obvious that this mode of conducting the silver meltings was extremely defective, and was in consequence abandoned.

The next experiments made were with a reverberatory furnace, built after the model of those used in the Lille mint. But no better success attended these trials, and the process was, as in former cases, abandoned. The imperfection here arose from the great refinement of the silver in the melting, by the oxidation of the alloy, and which the usage of the British mint does not allow the melter to supply, as in the French mints. In the French mints, as soon as the silver is in fusion, a sample is taken out and assayed, and copper is added in the proportion to the refinement of the melted silver (which is kept in fusion while the assay is making); the whole is well stirred, and immediately laded out and cast into bars.

In the years 1795 and 1798, several farther trials were made by the late Mr Morrison, who was indefatigable in his endeavours to perfect his department, with a view to attain the object so much desired,—that of melting large quantities of silver at once, without producing so much waste and refinement in the metal. In these experiments he tried three furnaces, each of a different construction; and though he was much nearer his point, there was still an imperfection, arising from the mode of dipping out the metal from the pot with ladles, which chilled the metal, and rendered the process extremely laborious and tedious.

No new experiments were made until the year 1804. Mr Morrison, having died in 1803, was succeeded in his office by his son, the present deputy-master and worker of the mint. The extreme scarcity and defective state of the silver coin at this time, arising from the defective state of the melting department, urged Mr Morrison to renew the experiments of his father. In following these experiments, Mr Morrison had in view the construction of a furnace adapted for the use of cast-iron pots,—the use of pots of a size capable of melting from 400 to 500 lbs. Troy, at one charge,—the adaptation of such machinery as would supersede the clumsy and wasteful process of lading the silver from the pots when melted,—and, lastly, the introduction of the use of moulds made of cast-iron, in place of those then used in the mint, and which were made of sand.

In all these objects Mr Morrison, highly to his credit, perfectly succeeded; and the silver melting department of the new mint was construct-

ed according to the furnace first used in the experiments which led to such a satisfactory result. The whole has been in use since 1811, and the department is capable of melting, with ease, 10,000 lbs. Troy of silver daily; as was done for several months during the late recoinage. (1817.)

We shall now proceed to a description of the machinery and furnaces of the silver melting department, together with the mode of conducting the process.

The upper part of Plate LXI. is a perspective view of the machine, for pouring the melted silver into the ingot moulds.

Fig. 1. AA, are the furnaces in which the metal is melted. These are air-furnaces, built of fire-brick, in the usual manner of melting furnaces, but, to render them more durable, the brick-work is cased in cast-iron plates, which are put together with screws. BB are the covers to the furnace; they are held down to the top plate of the furnaces by a single screw-pin for each; and, on the opposite side of the cover, a handle *a* is fixed. By pushing this handle, the cover is moved sideways upon its centre-pin, so as to remove it from the furnace mouth. A roller is fitted to the cover, to run upon the top plate, and render the motion easy.

The interior figure of each furnace is circular, 30 inches deep, and 21 inches in diameter; the bottom is a grate of cast-iron bars (each bar being moveable) to admit the air. Upon the grate is placed a pedestal or stand of cast-iron, of a concave shape, covered an inch thick with coke or charcoal dust, and upon which the pot is placed in which the silver is melted. The pedestal is nearly two inches thick, and is fully two inches broader in its diameter than the pot, the object of which is to protect the hip of the pot from the very high heat which the current of air ascending through the grate, when the furnace is at work, creates, and which would otherwise melt the pot. This precaution is essentially necessary, from the pedestal raising the pot so considerably above the grate, and from its being entirely surrounded by the fire in the furnace. If the furnace, however, is properly managed, there is no risk of melting the pot. On the top or mouth of the pot is placed a muffle, which is a ring of cast-iron, six inches deep, made to fit neatly into the mouth of the pot; the use of this muffle is similar to that used in melting gold, to give a greater depth of fuel in the furnace than the mere length of the pot, and which gives a greater degree of perfection to the process. The muffle is also extremely convenient, by giving a depth to the pot, if we may so speak, which enables ingots of silver to be charged, which are longer than the depth of the interior of the pot. The top of the ring or muffle is covered with a plate of cast-iron, to prevent the fuel from falling into the pot, and secure the metal from the action of the atmospheric air when in fusion. Each furnace has a flue 9 inches wide and 6 inches deep. The flue is 4 inches from the top of the furnace, and proceeds in a horizontal direction, and extends to the flue C, which is 9 inches square, and is carried up in a sloping direction to the stack or chimney, which is 45 feet high from the grate of the furnace.

When the furnace doors, BB, are closed, the current of air which enters at the grate ascends through the body of the furnace, and causes the fuel, which is coke, and which surrounds the melting pot, to burn very intensely. The degree of heat wanted, however, is very nicely regulated by a damper, which is fixed in the flue of each furnace, and exactly fitting the square of the flue, so that any portion of draught can be given to the furnace that may be wanted. The damper is a plate of wrought iron, fixed in a frame, and is easily moved in and out, so as to increase or diminish the size of the flue. It is fixed in the brick work of the sloping flue C, about 18 inches above the top of the furnace. The furnace doors B have small holes in them to look into the furnace; these are closed by stoppers or plugs of cast-iron.

When the furnace is put to work, it is lighted by some ignited charcoal being put upon the grate, and around the pot (for the pot is always in its place before the fire is lighted); upon the charcoal about three inches deep of coke is put—the door B is shut, and the damper is pulled out about two inches. When the coke is ignited, a similar quantity is put on, and so continued until the furnace is filled with ignited coke. The object of this precaution is to prevent the cracking of the cast-iron pot by being too suddenly heated—and it is generally about two hours before the pot can be brought to a charging heat, to do it with perfect safety. Before the silver is charged the pot is heated a bright red; it is then examined to see if it has cracked in bringing up, as it is technically called. This is done by placing a cold iron tool of considerable thickness in the centre of the pot, which immediately renders any crack visible to the eye. When satisfied that the pot is sound the silver is charged into the pot. With the silver is put into the pot a small quantity of coarsely grained charcoal powder, which coats the inner surface of the pot, and prevents the silver from adhering to it. When the silver is brought to the fusing point, the quantity of charcoal is increased until it is nearly half an inch deep on the surface of the silver, and which keeps the silver as much as possible from the action of the common air, and prevents that destruction of the alloy which would otherwise cause a considerable refinement in the metal. When the silver is completely and properly melted, it is well stirred with an iron stirrer, so as to make the whole mass of one uniform standard quality. The pot is then taken out of the furnace by the crane and conveyed to the pouring machine, by which its contents are poured into the ingot moulds.

Fig. 3. is the crane; it is supported by a strong column of cast-iron X, which is firmly fixed in masonry beneath the floor. The gibet of the crane marked WY is cast in one piece; it has a collar at *e* which fits upon a pivot formed at the upper end of the column X. At the lower part of the gib is a collar which embraces the column near its base. On these two supports the gib turns freely round, so that its extremity W may be placed over either of the

furnaces BB. The wheel-work of the crane is supported in two frames *zz*, which are fixed to the gib by three bolts; it consists of a cog-wheel *c*, upon the end of the barrel, on which the chain winds, and a pinion *b*, which gives motion to the cog-wheel. The axis of the pinion has a winch or handle (*a*) at each end to turn it round. The chain *d*, from the barrel, is carried up over the pully at *c*, which is fitted in a part of the gib immediately over the pivot at the top of the column X. The chain then passes over the pully W at the end of the gib, and has the tongs VT suspended to it. These are adapted to take up the pot between the hooks or claws T, at the lower ends. The two limbs are united by a joint like shears, and the upper ends V, are connected with the great chain by a few links. The pot has a projecting rim round the edge, and the tongs take this rim to lift the pot out of the furnace. The pot being wound up to the required height, by turning the handle *a*; the gib of the crane is swung round to bring the pot over the pouring machine, and it is lowered down into it, for the convenience of swinging the crane round a worm, which is fixed upon the column X at O, and a worm or endless screw is mounted in the frame *z* to work in the teeth of the wheel. The screw being turned by a winch on the end of its spindle will cause the gib to move round on the column.

Fig. 2. represents that part of the pouring machine in which the pot is placed. M is an axis which is mounted in the frame of fig. 1. by the pivots at its ends. To this axis is fixed a cradle, which receives the pot. The cradle is jointed together so as to open and shut, and the screw *m* draws the parts together until they will fit. The pot L is an arched rack, forming a continuation of the principal bars of the cradle. When the cradle is in its place, as in fig. 1. the rack L is engaged by a pinion K, and can thereby be elevated so as to pour out the metal at a lip or spout which is made in the edge of the pot for that purpose. The axis of the pinion K is turned by means of a winch D with a train of wheels DE, FG, and HI. The man who turns this winch stands before the pot, so as to see what he is doing. The frame of the pouring machine is sufficiently evident from the figure. It is so made as to leave an open space beneath for the carriage containing the ingot moulds.

Fig. 4. is a separate view of a pair of ingot moulds. The two parts R and S put together, and form a complete mould, as shown in fig. 5. The upper edge or mouth is a little enlarged to facilitate the pouring of the metal. The moulds are made of cast-iron. The part R has the bottom and one side formed on it, and the other half S has one side formed on it. Before the moulds are used, they are heated in an iron closet, which has flues surrounding it, and they are then rubbed on the inside with linseed oil.

PQ, fig. 1. is the carriage into which a row of these moulds are placed, as shown at 4, and they are screwed up close by two screws *pp*, so as to hold them tight; the moulds rest upon a plate, which is suspended by screws *q*, at each end, and can by that means be raised or lowered to suit different heights of moulds. The carriage is supported on four wheels QQ, which run upon a railway. PP is a rack fixed to the bottom plate of the carriage; in this rack a cog-wheel N, acts; the cog-wheel is turned by a pinion which has a handle O, fixed upon it; by turning the handle the carriage is moved along upon the rail-way; and any one of the moulds 4, can be brought under the spout of the pot 2: then, by turning the handle D, the pot can be inclined so as to pour the metal into the mould until it is full.

In the silver melting-house there are eight melting furnaces, two cranes, and two pouring machines. Each crane stands in the centre of four furnaces, freely commanding the centre of each, and conveys the pots to the pouring machine. The eight furnaces are worked three times daily, and each pot contains, upon an average, 420 lbs. Troy, making the total melting 10,080 lbs. There are four men to each four furnaces; each party pour their own pots, and the whole meltings are finished from the time of first charging in the morning, in little more than ten hours.

The whole of the silver meltings, as we before observed, are conducted under the superintendence of the surveyor of the meltings; and he allows no silver to be delivered to the company of moneyers by the melter, unless he has a written order from the King's assayer master, authorizing such delivery.

The meltings are performed by contract with the master of the mint and his first clerk, as melter. He is responsible to the master for all the bullion he receives, and delivers weight for weight, which renders his situation one of considerable risk and great responsibility. He also finds security for the due performance of the duties of his office.

The bars of silver, of the approved standard, are delivered over to the moneyers, in the same manner as we have detailed respecting gold. The moneyers also perform the various processes of the coinage under contract with the master of the mint, always delivering weight for weight. They also give security for the due performance of the duties of their office.

Operation of Rolling.

The first process to which the silver bars are subjected, is that of flatting, rolling, or laminating, in the rolling mill. The bars, before they are put through the rollers, are heated to redness, which makes them much easier rolled. They are heated in a reverberatory furnace.

When the gold bars are subjected to the same process, they are rolled cold, and a bar of an inch thick can be reduced to the thickness of a half sovereign without ever being annealed, and could be reduced much thinner if necessary, and not show the least symptom of cracking.

Fig. 6. is an elevation of one pair of rollers, and the wheel work for giving motion to them. A is the upper and B the lower roller; CC are the standards of the cast-iron frame which supports them. Each of these standards has a opening in it to receive the bearing brasses for the pivots of the rollers. The upper roller is suspended in brasses which are regulated by the large screws FF, which admit of placing the rollers at a greater or less distance asunder. This is shown by the separate figure of one of the screws; *hh* are the brasses, and *k* the hole to receive the pivot of the roller. On the upper part of the screw a collar *f* is fitted, and from this two bolts *gg* de-

scend, and are fastened to the brasses *hh*, with nuts beneath. By these the roller is suspended, but, by turning the screw round, the brasses rise or fall. The brasses *hh* are fitted very accurately into the grooves on openings in the standards CC.

For the convenience of turning both screws round together, each has a cog-wheel F fixed on the upper end of it. These are turned by two worms HH, fixed on a common axis, which has a handle G in front. See the plan, fig. 8. By turning this handle the upper roller is either raised or lowered, as is required, but will always be parallel to the lower one. The two standards CC, are firmly bolted down to the ground sills DD, which are of cast-iron, and are bedded in the masonry EE. The standards are farther united by bolts *a*. At the upper part S, is a cross bar fixed between the standards, to support a small table or platform, on which the metal is placed when it is to be presented to the rollers.

The rollers are put in motion by a steam-engine. The crank of the engine has a cog-wheel upon it which turns a pinion. Upon the axis of this is a very heavy fly-wheel, which turns with great velocity. On the end of the same axis, is a pinion which turns a large wheel M, and this gives motion to a long shaft NN, which extends beneath the rollers, and is continued a sufficient distance in the same direction, to turn two pair of rollers, one of which only are represented in the drawing. At L, a wheel is fixed on this shaft, to turn the upper roller A, by means of a wheel K, which is supported in the standards *kk*, and its axis is connected with a short shaft *r*I*r*, with the square on the end of the roller A. *rr* Are the sockets by which the shafts are joined, and they admit of a little yielding when the roller is raised.

The wheel O, is fixed on the shaft N, to turn the lower roller B, by means of the wheel P; but the wheels P and O do not touch, being of smaller diameters, and an intermediate wheel is applied on one side, so that its teeth engage with both the wheels O and P; by this means the two rollers A and B are made to turn round in opposite directions, and then their adjacent surfaces will move together. The wheel P is supported in standards *pp*, and its axis R is connected by a shaft Q, with the lower roller B.

Fig. 7. is a gauge so ascertain the thickness of the plates, which are reduced by the operation of the rollers; it consists of two steel rulers, fixed fast together at one end, and the other end is a certain distance asunder, forming an opening between them, which gradually diminishes to nothing. The sides of the rulers are divided. In using this gauge to determine the thickness of a piece of plate, the edge of the plate is applied to the opening between the rulers, and the divisions of the rulers show the distance it will go into the opening before it fits tight, and the thickness is ascertained by the number of the divisions.

Plate LXIII., figs. 3. and 4., represent the machine by which the plates of metal from the rolling-mill are cut into slips of a convenient width, for cutting out the circular pieces or blanks, which are to form the coin. This width is generally that of 2 crowns, $2\frac{1}{2}$ crowns, shillings, &c.

LL is a strong iron frame, which is screwed down to the ground sills of the mill, so that the cog-wheel D will be immediately over the shaft which turns the rolling-mill, and can be turned by a cog-wheel upon that shaft. The cog-wheel D is fixed upon an horizontal axis BB, which is supported in the frame LL. AA is a similar axis placed at the top of the frame, and turned round by a cog-wheel C, which engages with the wheel D. On the extreme end of each axis A and B, a wheel or circular cutters E and F is fixed. The edges of these cutters lie in close contact laterally, and overlap each other a little. The edges of the cutters are made of steel hardened, and they are turned very truly circular, and the edges which overlap are made very true and square. Whilst they are turning round, if the edge of a plate of metal is presented to them, it will be cut or divided just in the same manner as a pair of shears. H is a narrow shelf, upon which the plate is supported when it is pushed forwards to be cut, and G is a guide fixed upon the shelf; the edge of the plate of metal is applied against this guide, whilst it is moved forwards to the cutters. The guide is moveable, and the distance which it stands back from the cutting edges, or line of contact of the two cutters, EF, determines the breadth of the slip of metal which will be cut off.

To give these slips of metal the exact thickness which is requisite before they are cut up into blocks, they are subjected to a more delicate rolling; or they are drawn between dies by a machine, invented by Mr Barton, the present comptroller of the mint.

Fig. 7. Plate LXIII. represents the finishing rollers, viewed at the end of the frame, in order to show the manner of adjusting them; for it is only in those parts that they differ from the great rollers: *a* is one of the pivots or centres of the upper roller; it is accurately fitted in a collar of brasses, which collar is held down in a cell at the top of the standard by a cap *d*, with two bolts and nuts. These are not intended for the adjustment of the rollers as in the former instance, but the lower roller is moved for this purpose. The pivot *b*, of the lower roller, is received in a brass bearing, which is moveable, in the opening in the standard frame. The brass rests upon a wedge, *e*, which is fitted in a cross mortice through the standard. By forcing the wedge farther in the brass of the lower roller, it will be moved nearer to the upper roller. The standard at the other end of the rollers is made in the same manner, and the wedges of both must be moved at the same time. To give them motion, a screw, *f*, is fitted into each wedge, and upon these screws are worm wheels, *g*, which are both moved by worms cut upon an horizontal axis, then extends across from one side of the frame to the other, and has a handle at the end to turn it round by, and move the screws and wedges both in equal quantity; *l* is the table on which the metal is laid to present it to the rollers.

Plate LXII. contains drawings of Mr Barton's new machine for drawing the slips of metal between dies, by which a greater degree of accuracy is obtained in the thickness of the metal; the operation is similar to wire drawing.

Figs. 1. 2. and 3. represents a small machine for

thinning the ends of the slips of metal, so that they will enter into the dies, through which the whole of the slip is to be drawn. It is a small pair of rollers, which are shown on a large scale, in fig. 1.; A is the upper roller, and B the lower: this has three flat sides, as represented; C is the slip of metal put between the rollers; D is a stop adjustable in the line of the motion of the slip of metal C. Fig. 2. is an end view, and fig. 3. a side view of the frame or machine in which the rollers are mounted. AB are the rollers, which are made to turn round together by pinions *a b*. F is a large cog-wheel, which is fixed on the end of the axis of the lower roller. This cog-wheel is turned by a pinion G, which is fixed on an axis extended across the machine, and having a fly-wheel fixed on one end, and at the other a drum H, to receive an endless strap, by which the machine is put in motion; a crank is formed on the middle of this axis, and a rod *d*, is joined to the crank, to connect it with the moving blade K of a pair of shears, of which the other blade L is fixed to the frame. The distance of the rollers is regulated by a screw *ee*, at the top of each standard. These screws have pinions at the top of them, and are turned round by a pinion which is placed between them, and engages the teeth of both pinions, so as to give motion to the two screws at the same time, when the middle wheel is turned round by a cross handle which is fixed to the top of it. If the slips of metal which are to be put in this machine are not exactly square at the ends, they are cut off smooth and square by the shears, which keep constantly moving; the end of the slip is then presented between the rollers, not on that side which would draw them in between the rollers, as in common rolling, but on the opposite side; when one of the flat sides of the lower roller comes opposite to the upper roller, then the piece of metal can be pushed forwards between the two, until the end stops against the stop D, as in fig. 1.; then as the rollers turn round, and the flat side of the lower roller passed by, the cylindrical parts of the roller will take the metal between, and roll it thinner at the end which is between the stops and the point of contact of the rollers.

Fig. 5. is a perspective view of the drawing machine at work.

Fig. 7. and 8. a section to show how the slip of metal C is drawn between the dies by the tongs, fig. 7.

Fig. 4. is a section of the steel dies. They are two cylinders AB of steel, made very hard and extremely true; these are fitted into two sliders DD, and are held fast by clamp pieces EE screwed against them. The steel cylinders are very accurately fitted into their beds in the slides, so that the steel shall be firmly supported and prevented from bending or turning round, and presenting but a small portion of their circumference against the slip of metal. The sliders D are fitted into a box, fig. 8. and 9.; they fit flat on the bottom of the box, and two clamps FF are screwed against the sliders to confine them to the box. The lower slider is supported by two screws *ff*, and the upper slider is forced down by a large screw G; this has a cog-wheel fixed on the top of it, with a pinion and lever to turn the screws round very slowly, and regulate the distance between the dies. H is a clamping nut, fitted upon the screw, to take off all possibility of shake; the sliders are also bound fast sideways by screws tapped through the sides of the box, the points of which press upon steel plates between them and the sliders. In order to render the contact between the points of the screws, supporting the under slider and the point of the adjusting screw, forcing the upper slider, still more complete, two extending screws are introduced at the ends of the steel dies between the sliders, by which a sufficient degree of contact, to overcome the spring of the materials, may be excited before the dies come into action on the slip of the metal.

The box of dies is fixed at one end of a long frame, as is shown in fig. 5. This frame supports two axis, AA, one at each end. Upon these axis wheels are fixed to receive endless chains, BB, which move along a sort of trough or railway, formed on the top of the frame. The chains are kept in motion by a cog-wheel C, which is fixed upon the axis most remote from the box of dies. This cog-wheel is turned by a pinion D, on the axis of which is a wheel E, and this wheel is turned by a pinion F, on the axis of the drum G, which is moved by an endless band proceeding from some of the wheels in the mill, and which is thrown in and out of geer at pleasure by a tightening roller. The slip of metal is drawn through the dies by the chain, with a pair of tongs, fig. 6. and 7. *ab* are the two jaws of the tongs which are united with each other by the joint pin *c*. This has a small roller or wheel fitted on each end to run upon the railway on the top of the frame; *dd* are a similar pair of wheels, the axle of which is connected with two links *ee*; this axle passes between the tails of the tongs, but is not fixed to them. The ends of the links have a double hook formed on them as shown at fig. 7. The tongs run upon their wheels immediately over the endless chain, so that when the end *f* of the links *ee* is pressed down, one of the hooks catches on a cross pin of the chain, as in fig. 7. The axle of the wheels *dd*, acting between the inclined parts of the tails of the tongs, tends to throw them asunder, and, at the same time, the jaws of the tongs bite with very great force; the links *ee* draw the tongs along with the chain BB. The links are carried a long way beyond the axle of the wheels, and have a sufficient weight *h* fastened to them, which will lift up the hooked end *f*, and disengage it from the chain, except when there is a considerable strain on the tongs.

To use this machine, a boy takes hold of the tongs by the handle *r*, when they are disengaged from the chain, and pushes the tongs forward towards the box of dies. The tongs run freely upon their wheels, and the jaws open when moved in that direction, because two small pins *ii* are fixed across between the links, and acting on the outsides of the tails of the tongs, close them together, and this at the same time opens the jaws. The tongs are pushed up close to the box of dies, and the jaws enter into a recess N, fig. 8. which is formed for that purpose. Another boy takes a slip of metal, which is previously made thin by the rollers, fig. 1., and introduces it between the dies, and also between the

jaws of the tongs, which are open. The boy who holds the tongs now takes the handle *s*, which is fixed on the back of the tongs, and holds it fast, whilst with the other hand he draws the handle *r*, at the end of the links, away from the tongs. This has the effect of closing the jaws of the tongs upon the slip of metal between them; at the same time he depresses the handle *r*, and the hook at the end of the links *ee* will be caught by the first cross pin of the chain, which comes beneath them. This puts the tongs in motion, but the first action is to close the jaws and bite the piece of metal with great force, in consequence of the axletree of the wheels being placed between the inclined planes of the tongs. When the tongs have closed on the metal, with all their force, they move with the chain, and draw the slips of metal through the dies, which operating upon the thicker parts of the slip with greater effect than upon the thin, reduces the whole to an equable thickness. When the whole length is drawn through, the strain upon the tongs is instantly released; and the weight lifting up the hook at the other end of the links, they are ready to be advanced again to the dies, to draw another bar. The frame, fig. 5. contains two pair of dies, and the same wheel serves for both. At the mint are two machines like that shown in fig. 5. They are placed side by side, with a sufficient space for the boys to work between them.

These machines were made by Mr Maudslay, under the directions of the inventor.

The slips of metal produced from this machine are considerably more uniform in thickness than when finished at the adjusting rollers; consequently the individual pieces are made more nearly to the standard weight, which was the object in view by this invention. This has become a point of great importance in the practice of the mint, from the remedy on gold in weight being reduced from 40 to 12 Troy grains. When the pieces cut from slips of metal prepared by the drawing-machine are pounded and weighed, which is telling the number of pieces in a pound Troy, sovereigns or half-sovereigns, the variations from standard either way seldom exceed 3 grains Troy. It is reckoned good work from the adjusting rollers when the variations are under 6 Troy grains.

The plates of metal, prepared by the adjusting rollers or the drawing machine, are cut out into circular pieces nearly of the size of the intended coin. This is done by the cutting out press, fig. 1. Plate LXIII. CCCC is a cast-iron frame which is fixed on a stone basement. E is the screw which is fitted through the top of the frame and actuates a slider F. At the lower end of the slider a steel punch *a*, is fixed. Its diameter is exactly equal to that of the pieces which are to be cut out, *c* is the steel die, which has a hole in it of a proper size to fit the steel punch; *d* is a box with screws for adjusting the die, so that the hole in it will be exactly beneath the punch.

The slider F is fitted into a socket G, which guides it so that it will descend correctly into the hole in the die. *b* is a piece of iron which is fixed a small distance above the die *c*; it has a hole through to admit the punch. Its use is to hold down the piece of metal when the punch rises, otherwise the piece would stick to the punch.

On the upper end of the screw a piece Q is fixed, and an arm projects from it with a weight P at the end; and it is this weight which gives the necessary momentum to punch out the piece. D is a spindle fixed upon the piece Q in the line of the screw; it is supported in a collar A, at the upper end, and above the collar a lever DGF is fixed; at one extremity of this lever a roller F is fixed, and this is acted upon by projecting teeth, which are fixed in the rim of a large horizontal wheel, which is turned round by the power of the mill. This action is explained by fig. 2. which is an horizontal plan of the upper part of the axis. SS is part of the rim of the large wheel, and T one of the projecting cogs, which, when the wheel turns in the direction of the arrow, will take the roller F, at the end of the lever FD, and turn the lever round in that direction, which will wind up the screw and raise the punch out of the die. Also this action draws a rod H, which is connected with the lever by a joint; the other end of this rod is connected with a bended lever, from the other arm of which a rod descends and has a piston fixed to it. This piston is fitted into a close cylinder; hence, when the piston is drawn up, it makes a vacuum in the cylinder, and the pressure of the atmosphere on the piston causes a reaction, and the instant that the roller F escapes or slips off from the tooth T, the reaction of the piston draws the joint H back, and makes the screw turn round in that direction, which causes the punch to descend into the die, and it will pierce out a piece from a plate of silver or gold which is laid upon the die, which piece will be exactly the size of the punch, which, as before mentioned, is the same as the intended piece of money. When the machine requires to be stopped, a catch K, is suffered to rise up and hook the lever G, so that it cannot return by the action of the exhausted cylinder and pierce the plate. This catch is shown in fig. 8. At K it is moveable on a joint *l*, and is thrown upwards by a spring *k*. To this spring a cord O is fastened, and the lower end of the cord has a tradle fastened to it. The boy who applies the plates of metal to this machine places his foot upon the tradle, and draws down the spring and the catch K, and then the machine will make a cut every time that a cog T of the great wheel S passes by; but if the boy relieves the tradle, then the spring K lifts up the catch *k*, as in fig. 8., and when the end of the lever G comes over the catch, it will be caught thereby, and held fast from returning by the action of the exhausted cylinder. The joint *l* of the catch K is made at the top of a long lever *l*N, of which *m* is the centre pin, when the lever G is detained by the catch K; if the end N of the lever is drawn towards fig. 1. it draws the lever G still farther, so that the roller F will be raised quite clear of the tooth T of the great wheel, and prevents any unnecessary wear of the machinery when the process is stopped.

Twelve of the cutting-out presses, fig. 1. are arranged in a circle round the great wheel SS, which is turned by a steam-engine, and has a large fly-wheel fixed upon the same axis, just above

the wheel S, to regulate the motion. The stone basement on which the presses are fixed is circular, and the bearing A are all fixed in a circular iron frame, which is erected upon the stone basement by an iron column placed between each press. The whole forms a very handsome colonnade, and is placed in the centre of a circular room, which is lighted by a sky-light in the dome. The air-cylinders are concealed within hollow pilasters, which ornament the walls of the room, and appear to support the dome. The rod H is jointed to a piece *h*, which is fitted to slide upon the lever FG, and is moved by the screw I, so as to be fixed at any required distance from the centre, and give a greater or lesser effect to the reaction of the exhausted cylinder. R, fig. 1. is a strong wooden spring, against which the balance weight P strikes to stop its motion, when it has made its required stroke to pierce the plate.

This cutting-out machine was invented by the celebrated Matthew Boulton of Soho, who had a patent for it in 1790, and prepared it at that time for working the coining or striking presses, but having invented a better method of working the latter, he confined this plan to the smaller presses for cutting out the blanks.

The blanks after being cut out by the last mentioned machine, are carried to the sizing-room, where each individual piece is adjusted to its standard weight. The light pieces are selected for remelting: and the heavy ones, if not considerably beyond weight, are reduced to their standard weight by rasping their surfaces with a coarse rasp or file. The superior accuracy of Mr Barton's beautiful machine has considerably abridged the labour of this inelegant and unmechanical process.

The pieces thus adjusted, are in a state of great hardness from compression by the rolling and drawing processes, and by which, in fact, their latent heat has been squeezed out. They attain their softness again by being heated to a cherry red heat in a reverberatory furnace; after which, they are boiled in very weak sulphuric acid, which makes them very clean, and of a very white colour. When dried, either in warm saw dust, or over a very slow fire, they are in a state for the two next processes, which are the milling, and the coining or stamping.

Operation of Milling.

The operation of milling is to be performed round the edge, to prevent their being clipped or filed (which was a fraud commonly practised upon the ancient money made before the introduction of milling or lettering round the edge). The construction of the milling-machine will be easily understood from the inspection of fig. 5. and 6. Plate LXIII.; fig. 5. being an elevation, and fig. 6. a plan of the same. The parts which operate upon the piece of money, consist of two steel bars or rulers, *dd* and *ee*, the adjacent edges of which are cut or fluted. The bar *ee* is immoveable, being fastened down by two clamps *hh* to a cast-iron plate DD, forming the base of the whole machine; the other bar *dd* is prevented from rising by the pieces *gg*, but has the liberty of moving backwards and forwards in the direction of its length, and is guided in such motion by laying half its thickness in a grove formed in the plate DD. A rack CC is fixed to the moving ruler, which engages in the teeth of the wheel B, mounted on an axis lying across at right angles to the ruler, and supported at its ends by two standards rising up from the Plate DD. On one end of the axis, a handle is fixed for giving motion to the machine. Two blanks are put into the machine at the same time, as shown at fig. 6., and the ruler *ee* can be made to approach nearer or recede farther from the ruler *dd* by the two screws *ff*, to take in a different sized piece between them. The operation of the machine is very simple. Two blanks being placed between the edges of the rulers, the handle A is turned round half a turn, which moves the ruler *dd* endways, sufficient to mark the blank all round the edge. The two milled pieces are then taken out, and two other blanks are placed between the rulers; the handle A being turned half round in an opposite direction, carries the ruler *dd* back again to the position in which it first stood: thus two more blanks are milled, and so on. The machine is placed upon a strong wooden bench, to raise it to a convenient height for the man who turns the handle; the blanks are placed in the machine by a boy who is stationed on the opposite side to that where the handle is.

Operation of Stamping.

Plate LXIV. is the coining-press, which stamps the money. Fig. 1. is an elevation of the press; CC B is a strong cast-iron frame, which is firmly screwed down upon a stone basement by the screws *cc*; the upper part B is perforated perpendicularly to receive the screw DD. One of the steel dies which strike the coin, is fixed to the lower end of this screw by a box, 4, and the other die is fixed in a box, 6, which is fastened down upon the base of the press. The heavy balance weights RR, are fixed on the top of the screw, which, being turned round, presses the upper die down upon the blank piece of coin which is laid upon the lower die and gives the impression, a sufficient force being obtained from the momentum of the loaded arms RR. The motion is communicated to the screw by a piece A, which ascends to the ceiling of the coining-room, and is worked by a steam-engine, with machinery, in the apartment in the room over the coining room.

Eight presses, similar to No. 1., are placed in a row upon the stone basement, and very strong oak pillars are erected upon the basement, and reach to the ceiling. Each press is contained between four such pillars, and iron braces are fixed horizontally from one pillar to another on the opposite side. These braces support blocks of wood against which the ends RR of the arms strike, to stop them from moving farther than necessary, as, without such precaution, the hard steel dies would sometimes come in contact and be broken. The piece of blank coin is contained within a steel ring or collar, whilst it is stamped, and this preserves its circular figure. The ring is shown at a large size at W, in fig. 5. V is a three-pronged spring which always bears the spring upwards; the opening through the ring W is made to fit upon the neck of the lower die T, fig. 6. When the ring is dropped upon the neck of the die, the upper surface of the ring and of the die will be in one plane. The ring admits of being raised up up-

on the neck, and will then form a recess or cell, which is just adapted to receive a piece of money. The collar W is made to rise and fall upon the neck of the die by means of the levers GG, fig. 5.; these are fitted upon centre pins or joints in a large ring *gg*, which is placed on the outside of the box, fig. 6., containing the lower die T, and is fixed fast upon it, as shown at 5 and 6, fig. 1., by clamping the screws *gg*. The levers GG are forked at the outer ends to admit studs at the lower ends of iron rods EE, which rise up through holes in the solid metal of the press, and are united to a collar G, fitted on the upper part of the screw D. When the screw of the press is turned back, and the upper die is raised up, the rods raise the outside ends of the short levers G, and the inside ends depress the ring; a blank piece of money is laid upon the die, and when the screw is turned to bring the upper die down upon it, ready to stamp the impression, the levers G are released, and the triple spring V lifts the collar up, so that it surrounds the piece of money; and in this state the blow is struck. Immediately after the press returns by its recoil, and then the levers G force the collar down upon the neck of the die, and leave the piece free. The lower die is fixed in a box, fig. 6., by four screws *tt*, which admit of adjusting it with precision beneath the upper die. The box, fig. 6., is screwed down upon the base of the press by four screws. The upper die is shown at S, fig. 3., which explains how it is fastened to the screw; *vv* are four screws, by which the die is held in a box, fig. 3. The box is fitted into a ring or collar, as shown by the dotted lines, F: see also fig. 1. The arms of the collar F are attached to the rods EE, by two nuts at each end, and this makes the collar F and the box 3. always follow the screw, and keep a close contact with the end of the screw, which enters into a cell in the top of the box, fig. 3., but leaves the screw at liberty to turn round independently of the box.

Fig. 2. is a ring which is fastened by its screws, *ww* to the screw of the press; a claw V, descends from the ring, and enters into cavity *o*, in the edge of the box, fig. 3., which cavity is near three times as wide as the claw V, and therefore allows the screw to turn round for a certain distance without turning the box, fig. 3., but beyond the limits of this motion the screw and die will turn round together. The intention of this is to press the upper die down upon the coin with a twisting or screwing motion; but if the die was to rise up with a similar motion, it would abrade and destroy the fine impression; for this reason the notch *o*, is so wide as to allow the screw to return, and raise the die from immediate contact with the coin, before it shall begin to turn round with the same motion as the screw.

Fig. 4. is a box which is screwed over the box for the upper die, as shown in fig. 1., in order to keep the upper die firm in its cell.

The great screw of the press is made cylindrical at the upper and lower ends, where it is seen at DD. fig. 1., and these ends are accurately fitted in collars, which are bound tight by the screws *aa*; the real screw or worm, part concealed within the solid metal B, and has no other office than to force the die down, the guidance laterally being effected by the collars *aa*.

It now remains to show how the press is made to remove every piece of money which it strikes, and to feed itself with a fresh blank piece.

Fig. 1. HIK, is a lever, of which I is the fulcrum; it is supported on a bar Q, fixed vertically from the cheek of the press, and steadied by a brace *h*. The upper end of the lever is actuated by a sector 7, see fig. 7., which is fixed upon the screw D. When the screw turns round, the groove in the sector being of a spiral curve, will move the end H of the lever to and from the screw; and the lower end K of the lever being longer, it moves a considerable distance to and from the centre of the press. *b* Is a socket or groove in a piece of metal, which is fixed to the perpendicular bar Q, and the upper end of the lever H is guided in this groove, to prevent any lateral deviation.

The lever K gives motion to a slider L, fig. 8., which is supported in a socket O, screwed against the inside cheek of the press, and the slider 8 is directed exactly to the centre of the press, and on the level of the upper surface of the die.

Figs. 8. 9. and 10. represent three views of the slider and socket; NMO is a kind of trough or socket in which the slider runs; this slider is formed of two pieces hollowed out on the sides, which are put together, and the two pieces are held together by screws. O is the part by which the socket is fastened to the press. The slider is a thin steel plate *p*, see also fig. 10.; it is made in two pieces, P and *p*, which are united by the joint *q*. The extreme end is made with a circular cavity; and, when the two limbs shut together as represented, they will grasp a piece of money between them, and hold it by the edge; but, if the limbs are separated, the piece will drop out. The limb *p* of the slider is opened or shut by the same movement which moves the slider endways in its socket. Thus a plate L is applied flat beneath the socket MN, and has an edge turning up and applying to the upright edge of the socket. A pin is fixed into this edge, and is embraced by the fork at the lower end of the lever *k*, fig. 1. By this means the sliding piece L is made to move on the outside of the socket N. It is kept in its place by a fillet *k*, fig. 9., which is screwed to the upright edge of L, and the fillet enters a groove formed along the upper surface of the socket N.

The sliding piece L is made to move the steel slider within the socket by means of three studs, which project upwards from the bottom plate of L, fig. 10., at *rrs*, and pass through grooves in the bottom plate of the slider, so as to act upon the steel slider P, in the manner shown fig. 10. The left hand piece *r* is received into an opening in the middle of the slider P, fig. 10. The other two studs *r* and *s* include the shank of the limb *p* between them, and these studs are cut inclined, so that, when the piece L is moved to the right, the studs *rs* will close the limb *p* until they are shut, and then the studs will carry the slider forward; but, if the sliding piece L is moved to the left, its studs will first close the limbs, and will then draw back the slider. On the top of the socket N a tube M is placed, and it is filled with blank pieces of coin; the

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tube is open at the bottom to the slider, and the pieces rest upon it. When the screw of the press is screwed down, the slider P draws back to its farthest extent, and the circle formed at the end between its limbs comes exactly beneath the tube M; the limbs being open, a blank piece of coin drops down into the circle of the slider, then the screw of the press, in returning, moves the lever HIK and the piece L; this acts by its studs upon the moveable limb *p*, and closes it upon the blank piece; the studs having now found a reaction, push the slider P forwards in its socket, and carry the piece forward upon the die, as shown in fig. 1., and which will push off the piece last struck. The screw having now arrived at its highest position, begins to descend, and the slider L to return; but the first action of the studs of the sliding piece L is to open the limb *p*, and then the slider withdraws, leaving the piece of money placed upon the die. As the screw of the press descends, the ring W, fig. 5., rises up to enclose the piece as before mentioned, whilst it receives the stroke, and the slider P at the same time returns to take another piece from the tube M in the same manner as before described.

Fig. 11. is a section to show the manner of mounting the lower die for a coining press. This is used in the French mint. V is a piece of metal or box, as it is placed upon the base of the press, and held down by a ring with screws *t*; this holds it fast, but admits of lateral adjustment. In the top of the box is a hemispherical cavity to receive the hemisphere W; the upper side is flat, and the die T is placed upon it, to hold the die down; it has a small projecting rim at the lower edge, and a rim X is screwed upon the outer edge of the box V, and binds the die down. The object of this plan is, that the die may always bear fairly to the money which is to strike.

Figs. 12. and 13. is a divided collar invented by Mr Droz, for striking money with the letters round the edge. X is a very strong piece of iron, which has a circular opening through the centre; into this, six segments *ww* are fitted, and between them they leave an opening W, the size of the piece of money; the interior edges of these segments are engraved with the pattern or device which it is required to impress upon the edge of the piece. The segments are fitted in the piece X by centre pins *y*, fig. 12., upon one of which pins each segment can rise in the manner of a centre.

The intention of this is to have a piece of money placed on the die within the space W; then, when the pressure is made upon the piece, the die descends some space, and by this motion the segments close together around the edge piece, and imprint upon the edge of it. When all the segments come into one plane, the die arrives at a firm seat, and the metal receives the stroke which make the impression on its surfaces. The die is suspended in a sort of cup, which rises and falls with the screw, nearly the same as the collar F in fig. 1.

Disposal of the Coined Pieces.

The coining room is under the superintendence of the surveyor of the money presses, whose duties we have already described. The money, when struck, is inspected under his directions, and passed through tubes of diameter, of the different species, which readily detects any pieces which may have been improperly struck. The moneyers cannot coin, but in his presence, as he has every press under lock and key.

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The money when examined is weighed up in journey weights for delivery to the importers of the bullion. The gold in 15 lbs.; the silver in 60 lbs. Troy.

Process of Pixing.

Before this money, however, is delivered to the importers, it is carried to the mint office, to undergo inspection, and to be pixed. The inspector examines the coin as to its workmanship, and may reject it if faulty. The process of pixing is more important, as by it the perfection of the money, as to weight and fineness, is determined before it is delivered to the importers. The process of pixing, as it is called, consists in taking from every journey weight of gold and silver, a pound in tale promiscuously, by the weigher and teller. This is weighed in a very accurate balance by the King's assayer master, who declares aloud the minus or plus upon each lb., and which is recorded by the comptroller, King's clerk, and King's assay master. This determines whether the company of moneyers have made the money within the remedy allowed upon the pound Troy. As the remedy, however, upon the pound Troy is divided among the number of pieces in it, the same pound weighed is handed to the comptroller, who, in a delicate balance, weighs several pieces individually; and, if they exceeded the remedy, he could, in conjunction with the other check officers, order the coin to be remelted and recoined at the expence of the moneyers. From the same pound weight of silver or gold, the comptroller takes two pieces; the one for the King's assayer master to assay, in order to prove that the company of moneyers have in no way or degree deteriorated the quality of silver or gold in any of their processes, or from the time of its having come into their possession. The other piece is ensealed in a packet, and put into a box (called the pix-box), which is locked up under the separate keys of the said officers, there to remain until the final trial of the pix by jury, before the King, or such of his Council as are usually appointed at Westminster or elsewhere, for that purpose. When the King's assay master has proved the piece delivered to him to be of the right standard (and which, in this case, is taken as the average of the whole journey weight), he authorizes the money to be delivered to the importers of the bullion. During the period, however, in which the assay is making, the money is deposited in the strong-room of the mint treasury, under the separate keys of the master, comptroller, and company of moneyers. The money is delivered over to the importers by the weigher and teller, and in the presence of the master, comptroller, King's clerk, and one of the moneyers; the master receiving a receipt for the same, as described in the duties of the deputy-master and workers.

As the trial of the pix at Westminster is very ancient and curious, and though done in an open court, is yet so little known, it may not be uninteresting to trace it from the earliest period in which it is to be found in our records,—to state the changes which it has undergone, and the manner in which it is conducted in the present times.

The Rev. R. Rudding, to whom we acknowledge

ourselves much indebted for much valuable information in the preceding pages, gives the following account of the trial of the pix.

"It does not appear that the ancients had any such public trial; and the earliest notice of the pix, which I have met with in any modern foreign mint, is in the reign of Philip VI. of France, in the fourteenth century; but whether the passage in which it occurs relates to a public trial, cannot be determined.

"The invention of it in this kingdom, or at least its introduction into our courts, is probably of high antiquity, for in the 9th or 10th of Edward I. it is mentioned as a mode well known, and of common usage. In one of those years the King, by his writ, commanded the Barons of the Exchequer to take with them Gregory de Rokesle (then master of the mint), and straightway, before they retired from the exchequer, to open the boxes of the assay of London and Canterbury, and to make the assay, *in such manner as the King's Council were wont to do*, and to take an account thereof, so that they might be able to certify the King touching the same, whenever he should please.

"From this record, which is the most ancient hitherto discovered relating to this trial, it appears that, previous to the above date, it had usually been made before the King's Council, but that, by the authority of the writ above quoted, it was then to be held in the Court of Exchequer, in the presence of the Barons. It was afterwards taken from their cognizance, and came again under the power of the Lords of the Council in the Star Chamber, where it is found to have been in the year 1595 (as appears from a verdict of that date), and where it continued until 1699, when it again became subject to the Court of Exchequer; under which it has remained to the present time.

"From memoranda of assays, which are still preserved in that court, it seems that this trial used to be annually; and the same is stated to have been the regular practice until the usurpation, when it was held at such times as the state pleased. At present, I believe it is not customary for the master to require it to be held until, upon his removal from the office, it becomes necessary, in order that he may receive his quietus.

"As the authoriry under which these trials are held occasionally varied, so did likewise the persons who sat as judges in the court. Thus, as we have seen above, they were first the members of the King's Council, then the Barons of the Exchequer, and again the members of the Privy Council, as judges of the Star Chamber, where sometimes the King himself presided; as did James I. at an assay, which was made upon the 9th May 1611.

"In 1643, a committee of Lords and Commons was appointed by order of Parliament, for the purpose of making this trial.

"At one period (in 1649), the court was held before the Lord President of the Council of State, the Commissioners of the Great Seal, and others of the Council of State, and Committee of Revenue, by virtue of an act of Parliament: at another (in 1657) by the Lords Commissioners of the Great Seal, assisted by the Lords Commissioners of the Treasury, the Justices of the several Benches, and Barons of the Exchequer, or some of them, under the authority of a warrant signed by the Protector Cromwell; and it is now composed of such members of the Privy Council, as are expressly summoned for that purpose; the Lord High Chancellor, or, in his absence, the Chancellor of the Exchequer, presiding.

"The manner in which this trial was formerly conducted in the Court of Exchequer appears, from a verdict of the 11th year of Henry VI. to have been by an assay, made in the presence of the court, and of other persons who were appointed to assist, by the King's assay master, and to have been determined without the intervention of a jury.

"The earliest notice which has occurred, in which the judgment of professional artists was required to sanction, as a jury, the judgment of the court, is dated in the 37th of Elizabeth; when a trial was held in the Star Chamber.

"The number of the jurors has occasionally varied considerably. No less than nineteen names appear to the verdict of the 37th of Elizabeth; and in 1651 the moneyers speak of a jury of twenty-four men, whilst the number usual at the present time is no more than twelve.

"As I have not been able to discover any ancient ceremonial, by which the forms of this trial were regulated; I must now proceed to state the modern practice of summoning the court, and conducting the business of it.

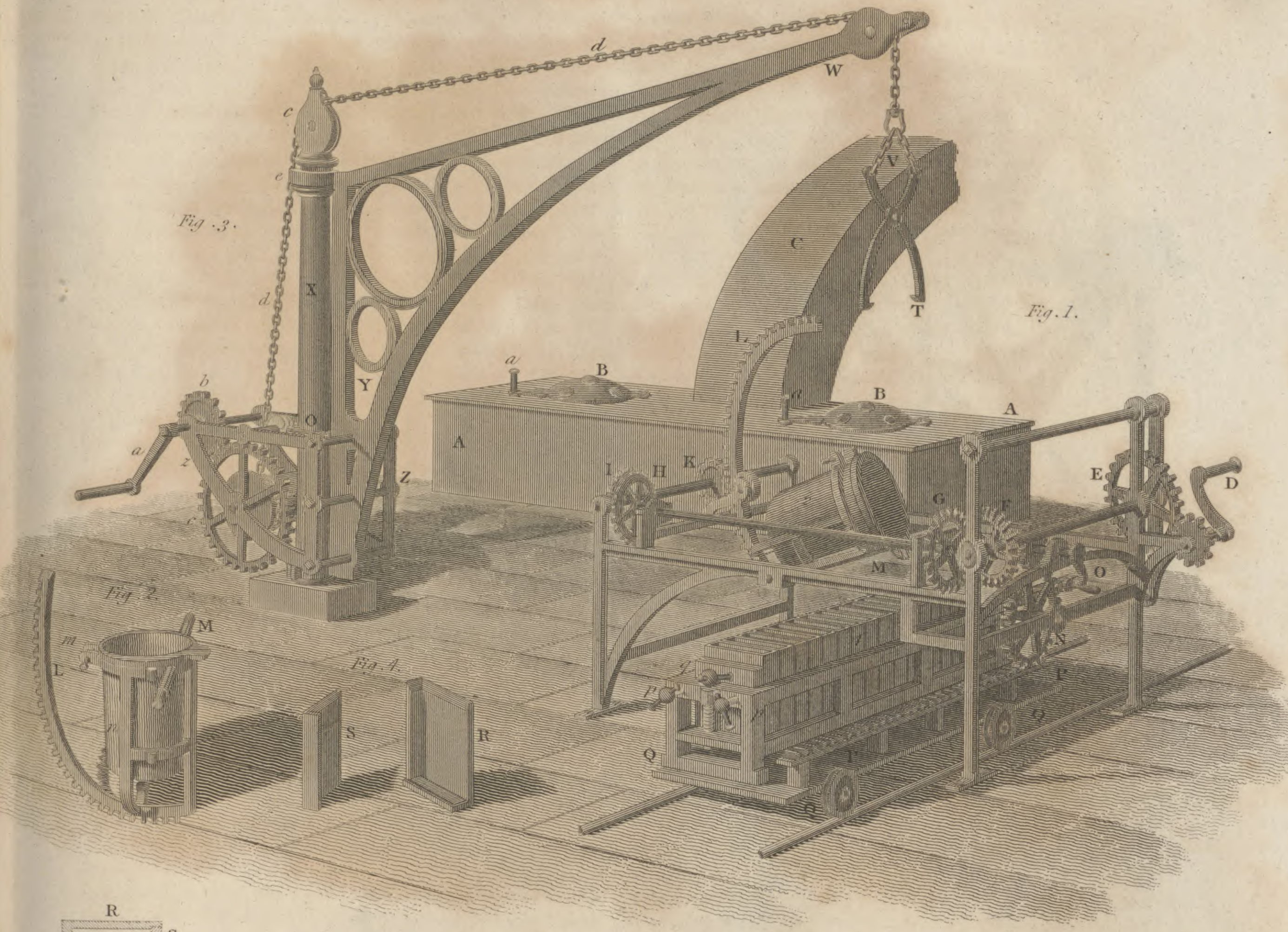
"Upon a memorial, being presented by the Master of the Mint, praying for a trial of the pix, the Chancellor of the Exchequer moves his Majesty, in Council, to that purpose. A summons is then issued to certain members of the Privy Council, to meet at the house, which is now allotted to the office of Receiver of the Fees in his Majesty's Exchequer, at eleven o'clock in the forenoon, on a certain day. A precept is likewise directed, by the Lord High Chancellor, to the Wardens of the Goldsmiths' Company, requiring them to nominate, and set down, the names of a competent number of sufficient and able freemen of their company, skilful to judge of, and to present the defaults of the coins, if any should be found, to be of the jury, to attend at the same time and place. This number is usually twenty-five, of which the assay master of the company is always one.

"When the court is formed, the clerk of the Goldsmiths' Company returns the precept, together with the list of names; the jury is called over, and twelve persons are sworn. The president then gives his charge, which was formerly to be general, like the oath, to examine by fire, by water, by touch, or by weight, or by all, or by some of them, in the most just manner, whether the monies were made according to the indenture, and standard trial pieces, and within the remedies. But, in 1754, the Lord High Chancellor Talbot directed the jury to express precisely how much the money was within the remedies, and the practice which he thus enjoined is still continued. The other parts of the charge necessarily vary, according to the ability of the president, and his knowledge of the subject.

"When it is concluded, the pix is delivered to the jury, and the court is commonly adjourned to the house of the president, where the verdict is afterwards delivered.

"The jury then retire to the court-room of the duchy

Machine for casting the Ingots of Silver, at the Mint.



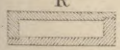
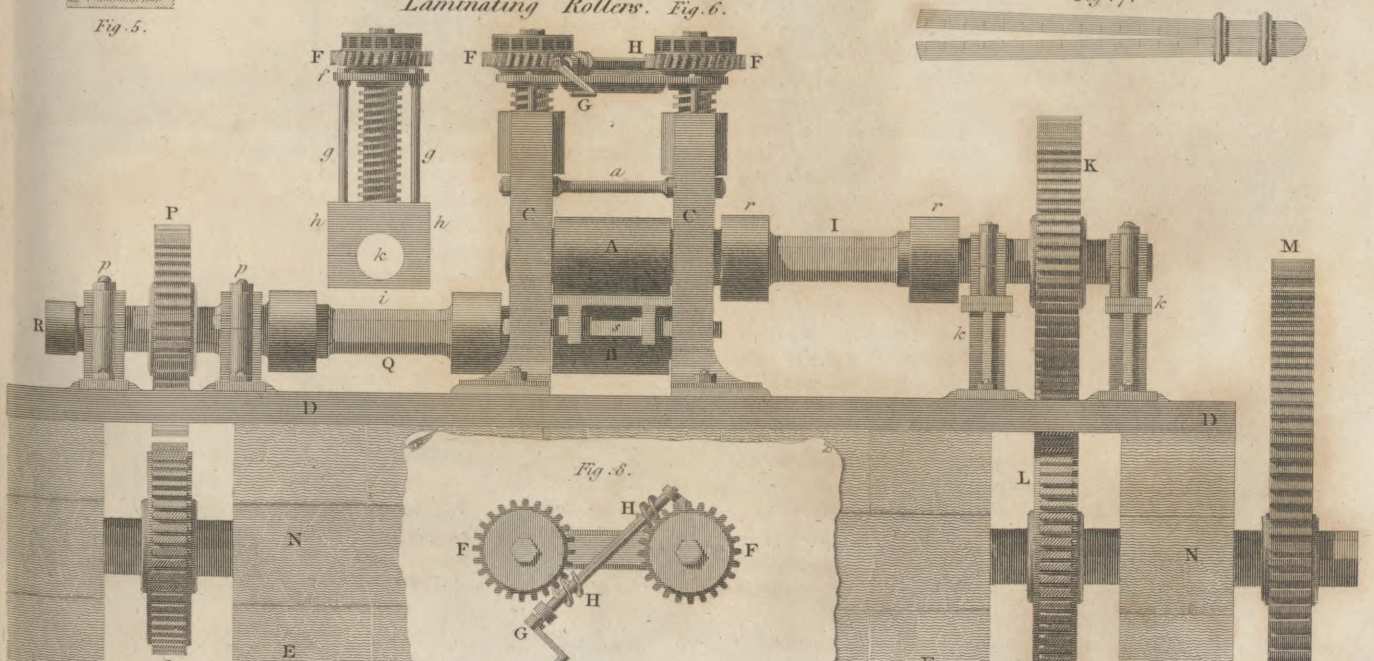


Fig. 5.

Laminating Rollers. Fig. 6.



J. Farey delin.

E. Turrell sculp.

Published by A. Constable & Co. Edin. 1818.

COINING.

PLATE LXII.

Machines used in the Mint.

Fig. 4.

Fig. 1.

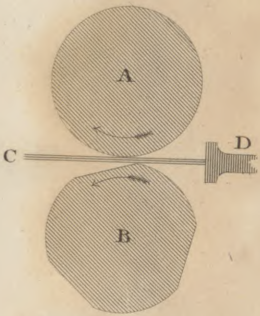


Fig. 2.

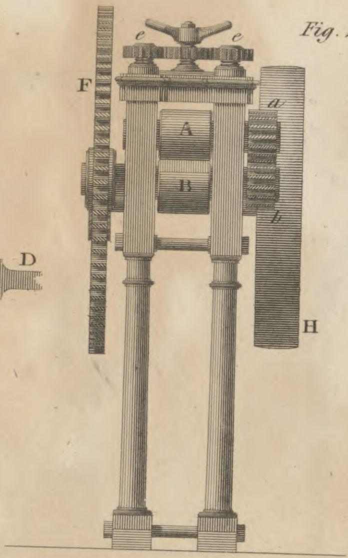
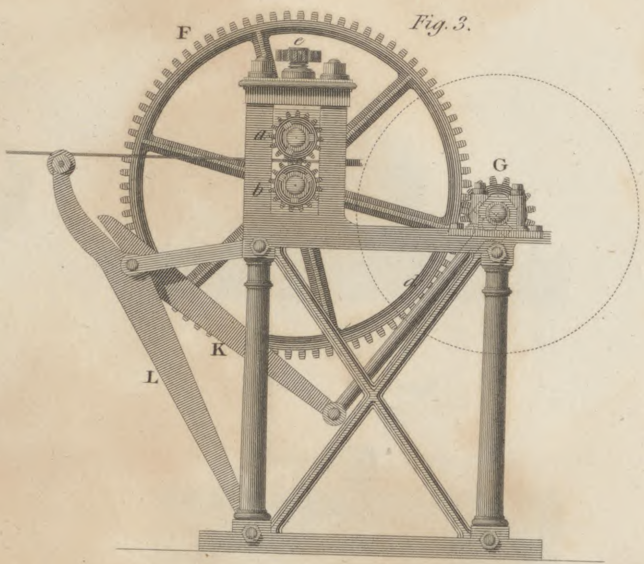


Fig. 3.



Mr. Barton's Machine for reducing Plates of Metal to an equal thickness.

Fig. 6.

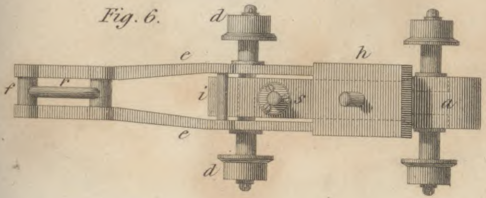


Fig. 7.

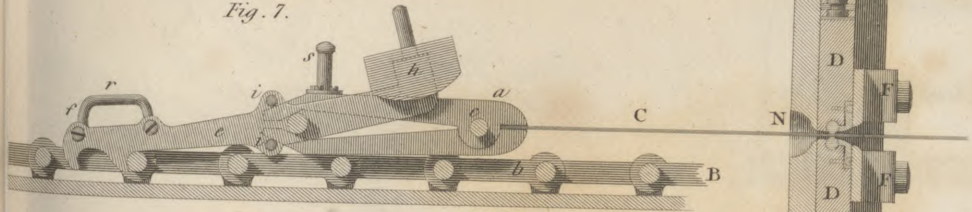


Fig. 8.

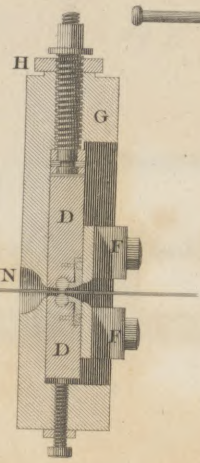
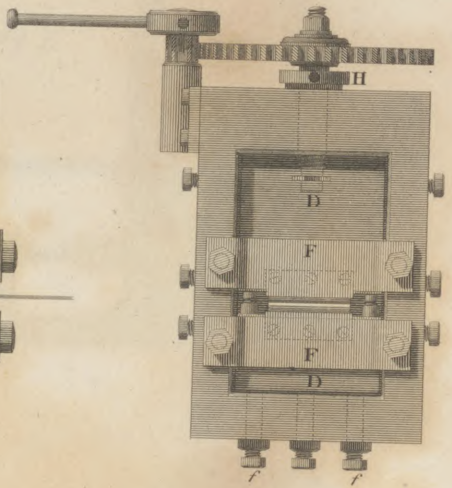
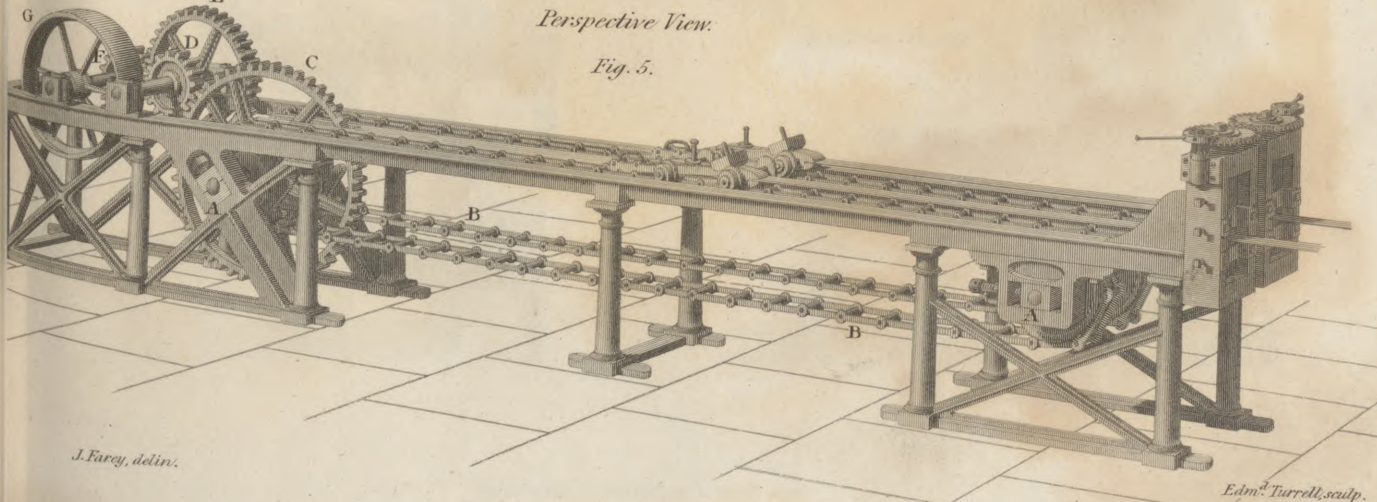


Fig. 9.



Perspective View.

Fig. 5.



J. Farey, delin.

Edmd. Turrell, sculp.

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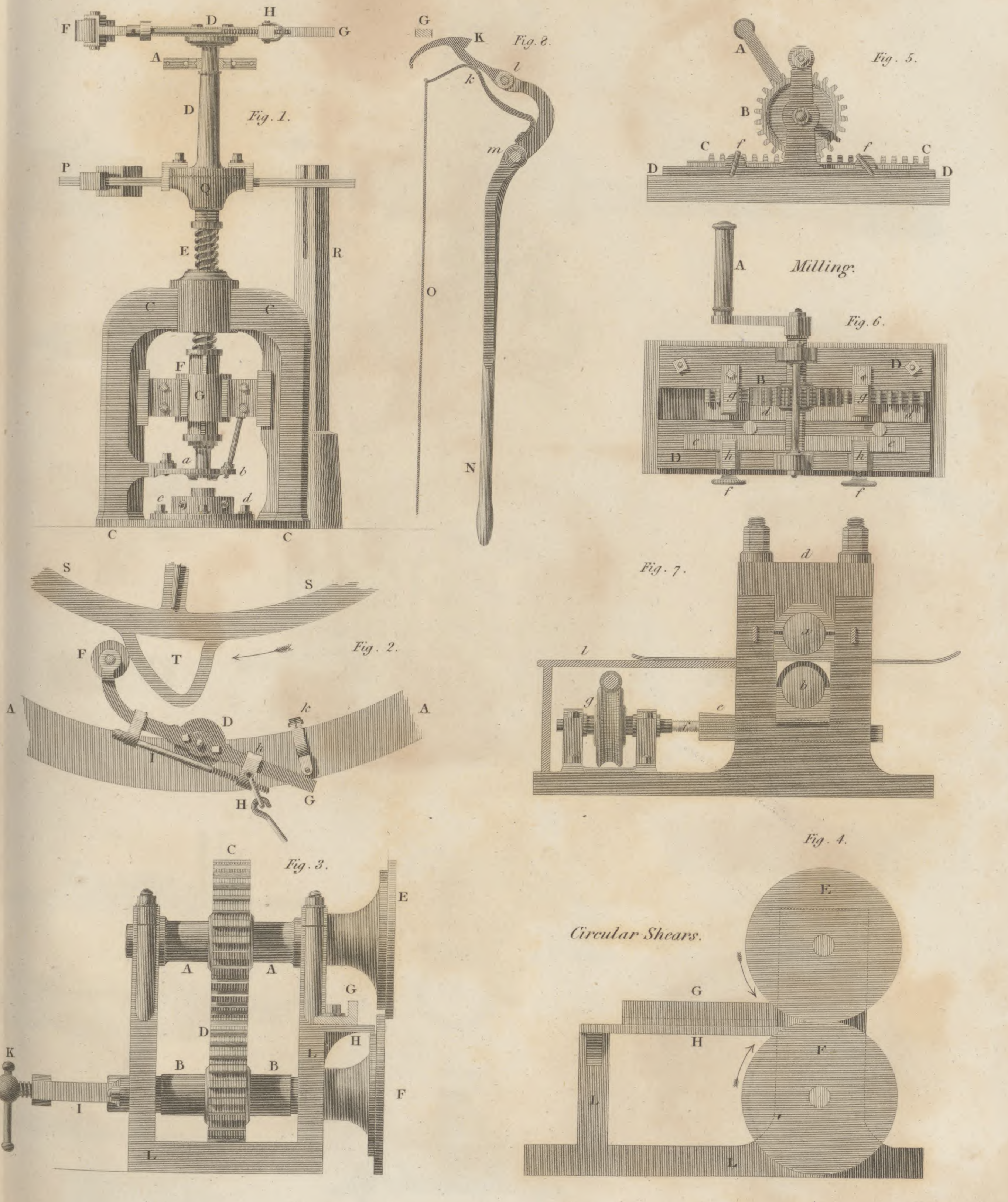
COINING.

MACHINES used in the MINT.



J. Farey, delin.

E. Turrell, Sc.

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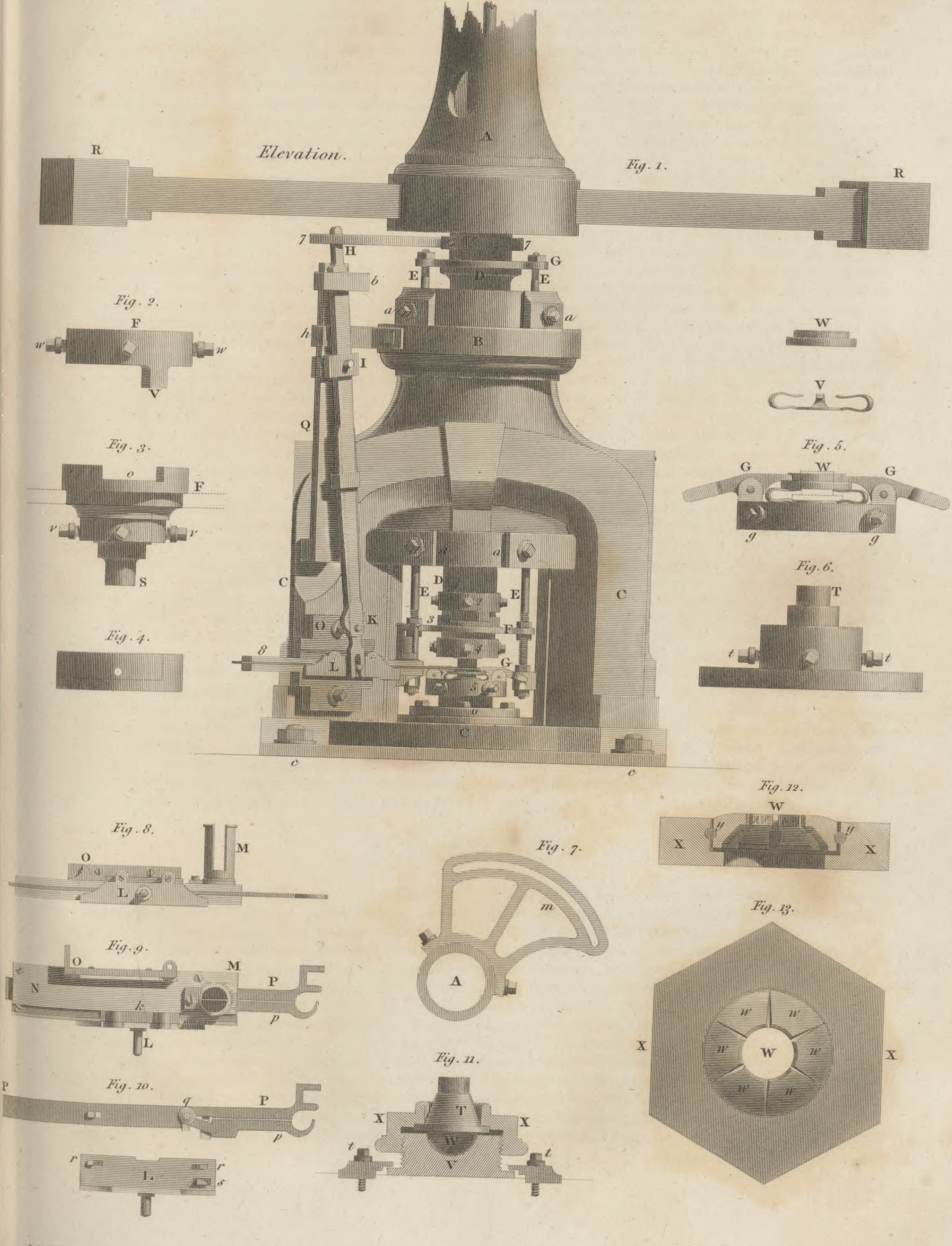
COINING PRESS used in the ROYAL MINT.



J. Farey delin.

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E. Turrell Sc.

Coinage || Cold.

of Lancaster, whither the pix is removed, together with the weights of the exchequer and mint, and where the scales which are used upon this occasion are suspended, the beam of which is so delicate, that it will turn with six grains, when loaded with the whole of those weights, to the amount of 48 lb. 8 oz. in each scale.

"The jury being seated, the indenture, or the warrant under which the master has acted, is read. Then the pix is opened, and the money which had been taken out of each delivery, and enclosed in a paper parcel, under the seals of the warden, master, and comptroller of the mint, is given into the hands of the foreman, who reads aloud the indorsement, and compares it with the account which lies before him. He then delivers the parcel to one of the jury, who opens it, and examines whether the contents agree with the indorsement.

"When all the parcels have been opened, and found to be right, the monies contained in them are mixed together in wooden bowls, and afterwards weighed.

"Out of the said monies so mingled, the jury take a certain number of each species of coin, to the amount of one pound weight, for the assay by fire; and the indented trial pieces of gold and silver, of the dates specified in the indenture, being produced by the proper officer, a sufficient quantity is cut from either of them, for the purpose of comparing with it the pound weight of gold or silver which is to be tried (after it has been previously melted and prepared) by the usual methods of assay.

"When that operation is finished, the jury return their verdict, wherein they state the manner in which the coins they have examined have been found to vary from the weight and fineness required by the indenture, and whether, and how much, the variations exceed, or fall short of, the remedies which are allowed; and, according to the terms of the verdict, the master's quietus is either granted or withheld."—*Archæologia*, Vol. XVI.

Method of Making the Dies.

We shall conclude our observations upon the subject of coinage, by detailing the mode of manufacturing the dies. An original die is engraven upon a piece of soft cast steel, of the size of the money to be made. The table of the die must be perfectly level or square. The impression engraved is, of course, cut into the steel, and its depth in proportion to the relief ultimately wanted upon the coin. When the engraving is finished, the die, or matrix, as it is called, is hardened. This is a very nice process, and requires considerable care to perform it. The die is put into a cast iron pot, completely embedded in animal charcoal, chiefly made from leather. The pot is placed in an air furnace in which coke is burned, which gives a more steady and uniform degree of heat. The square of the furnace is also considerably larger than the pot, that the die may have the greatest possible equality of temperature. When the die has attained its proper degree of heat, it is withdrawn from the furnace, and immersed in a large cistern of water, the temperature of which is kept as uniform as possible by a stream of cold water constantly flowing in and out of the cistern, while the process of hardening continues. It frequently happens, that in this process (either from the steel being faulty or heated to excess) the die will fly in pieces, and the whole labour of the artist is lost. When, however, the matrix is perfect, it is placed in the multiplying die press, which works in every respect like a coining press, but moved by men. An impression is taken from the matrix upon a blank die of cast steel, similar to the mode of impressing the money. The blank die is fixed as the lower die of the coining press; and, by working the screw of the press, which has very long and heavily loaded arms, the matrix is made to strike the blank die with great force, and bring its impression in *relief* upon its surface. The hardness, by compression of the steel, is so great, that an impression of the matrix cannot be obtained without annealing the die perhaps twice or three times, which is done in iron pots, as in the case of hardening, but are allowed to cool gradually. An impression taken in this way is called a puncheon die. When the engraver has given all the delicate outlines of the original to it, it is hardened in the same manner as its original, and used to give impressions to blank dies by a similar process, the impression being *sunk* into the dies, which dies being used for coinage, gives the impression in *relief* to the money.

This important department of the mint is under the superintendence of the clerk of the irons, who never suffers the multiplying press to be used but in his presence. He has also the care of all the dies, and must account to the Board of Management for all matrixes, puncheons, and dies, made and destroyed in the mint.

(A. A.)

COLD.

Cold is only Relative.

It is often disputed whether Cold has any actual existence, or should be considered as merely the privation of Heat. Nor is that question of a modern date; Plutarch attempted to discuss it, in his Tract *De primo frigido*, and the reasonings which he there employs, though abundantly vague, are yet curious. Cold, he says, affects the senses as well as heat; and it is not less active, since it condenses and consolidates bodies. He, therefore, inclines to the opinion, that cold is a distinct and independent power in nature. With the Stoic philosophers, he regards air as by its constitution cold and dark; and hence water drawn from a well freezes on being exposed to the atmosphere, while rivers overshadowed by high banks seldom freeze, and even where their surface congeals, the heat is not exhaled, but only driven down nearer the bottom.

The Diminution of Heat.

It is contrary to sound physics to admit more principles than are indispensably required, and this argument alone may be sufficient for the rejection of cold as a distinct power in nature. What we term cold, in reference to our feelings, is merely the diminution of heat. But the existence and materiality of heat rest on a very different foundation. The introduction of heat into a body is accompanied by the infusion of a certain extrinsic repulsive force, and its passage through the mass is connected with a series of depending internal motions, which imply the regular expenditure of time and ve-

Cold.

locity. The contraction which follows on the diminution of heat, is due to the mutual attractive powers of the particles of the substratum, now exerted with less opposition. That expansion, again, which some fluids manifest in the act of congelation, proceeds from the operation of the principle of crystallization, with the recondite nature of which we are still unacquainted.

Concentration of Cold by Reflexion.

The notion that cold has a separate and independent existence appears, however, to receive some countenance, from the elegant experiment of collecting and concentrating the frigorific impressions in the focus of a metallic reflector. This curious fact is one of the oldest in physical science, but again lately revived, and combined with circumstances of peculiar interest. The experiment was first mentioned about the year 1590, by Baptista Porta, in the enlarged edition of his *Magia Naturalis*, when the four books of which it originally consisted were augmented to twenty, at the very time that his ingenious countryman, Sanctorio, had invented and applied to medical purposes the air-thermometer. Porta relates, that, if a shut eye be held in the focus of a speculum before which is placed a ball of snow, intense cold will be felt on the eye-lid.* Cavalieri, the celebrated discoverer of infinitesimals, in his work on the conic sections, printed in 1632, and entitled *Lo Specchio Ustorio*, extended the experiment to all impressions which he conceived to be propagated in straight lines—not only to those of heat and cold,—but to those of sound and even smell.† It was afterwards frequently repeated at Florence, by the Academy del Cimento, with the important addition of the thermometer, which that learned body had the merit of introducing into practice. Similar experiments were next performed by Mariotte in France.

Specula and burning glasses appear, in the sequel, to have been allowed to fall into great neglect. We find scarcely any mention of their application to physical researches, till after the lapse of more than half a century, Kraft repeated, at St Petersburg, during the severe winter of 1740, the frigorific experiment of the Italian philosophers, with a reflector belonging to the Cabinet of the Imperial Academy. Ambitious to operate on a grand scale, he selected three huge blocks of clear ice, nearly of a cubical form, each side being 2, 4, and 5 feet; but to save the trouble of transporting them, he carried the speculum out of doors. No sensible effect, however, was then perceived by him, though he used the air thermometer on account of its extreme delicacy. In 1744, this Academician again resumed the observation, and with scarcely better success, having obtained only a doubtful cold of three degrees. The cause of the failure was evidently, his performing the experiment out of doors, and not in a warm room. The blocks of ice had, by long standing, acquired almost the same temperature as their ambient medium. Had the air happened to become suddenly colder, they might, from their relative condition, have excited impressions even of heat, and thus have perplexed philosophy for many years afterwards.

Unsatisfactory Results.

Such unsatisfactory results, from the action of a mass of ice of above a ton weight, seem, for a long time, to have shaken the belief in former experiments; and the subject was almost forgotten, when Pictet of Geneva, in 1781, repeated the original observation on a small scale, indeed, but with entire success. Since that time, a pair of brass reflectors, with a wire case for holding charcoal or snow, has been deemed an essential apparatus in every physical cabinet. The concentration of cold in the focus of a speculum, always excites surprise; and the experiment is often exhibited with a sort of mysterious air, as if

Resumed by Pictet.

* Si quis candelam in loco, ubi spectabilis res locari debet, apposuerit, accedet candela per aërem usque ad oculos, ut illos calore, et lumine effendet; hoc autem mirabilius erit, ut calor, ita frigus reflectitur, si eo loco nix objiciatur, si oculum retigerit, quia sensibilis, etiam frigus percipiet.

† Cavalieri mentions that, with a spherical speculum made of lead and indifferently polished, he was able to inflame dry substances by the reflexion of a charcoal fire; and that, with a deep truncated parabolic speculum badly polished, he produced the same effect in the open focus, from a small fire of wood at the distance of five feet.—Esperienza di questo hò fatto io, che con vno Specchio sferico di piõbo ancor mal polito, hò acceso il fuoco nella materia arida al fuoco di carboni; e di più l'hò fatto con la superficie parabolica, cioè con vn cánone parabolico, che hauea il suo foco vicino alla cima, essendo esso specchio parabolico trõcato pur nella cima, qual' era di stagno, e mal polito, tal che opponendolo al fuoco, ò alla fiamma di ben poca legna, nella distanza di tre braccia, ponendo la mano lì, dou'era la parte trõcato, et il foco della parabola, non vi si potea sostenere, anzi vi s'accese fuoco; la qual cosa potria alcuno applicare al riscaldamẽto delle stanze, ò alle distillationi, pp. 85. 86.—In general, says this ingenious mathematician and philosopher, the same form of speculum which concentrates light and heat, must likewise collect cold, which spreads from its source, from a mass of snow, for instance, in straight lines. The hyperbola is, therefore, the figure which he thinks the best adapted for the purpose; and he proposes this for condensing the smells radiated from an odoriferous substance.—Hora dunque basterà quello, che si è detto di sopra intorno al lume, e calore, *potendo noi nell'istesso tempo intendere le medesime cose anco per il freddo, che dilatãdosi dal corpo freddo ad ognii positione per linea retta, e perciò nell' infinite linee, che si partono dal corpo freddo, come dalla neue*, essendoui dentro le parallele, che sone vnite dallo specchio parabolico, e le diuergenti, che sono vnite dall' elittico, e le conuergenti vnite dall' iperbolico, con opporre alcun di questi specchi ad vna massa di neue, ò di ghiacco, sentiremo nel loro foco essere il freddo fatto molto gagliardo, ma per questo effetto sarà più atto l'iperbolico di tutti, come quello, che raccoglierà maggior quantità di linee fredde; e questo basti ancora circa il freddo, potendosi forsi in vn certo modo creder, *che tale effetto accadesse anco intorno à gli odori, prouando noi dilatarsi pur quelli dalli corpi odoriferi verso ogni banda.* Id. p. 128.

Cold.

it established, or at least rendered probable, the distinct and material existence of cold. But, in fact, it is not more difficult to conceive the impressions of cold to be collected than those of heat. Both those impressions are only relative to the temperature of the atmosphere, which serves as the medium of their transmission. The one process terminates with the deposition of a portion of heat, the other with its abstraction.

Sources of Cold.

The diminution of heat, or the increase of cold, is produced in Nature under four different circumstances: 1. By the obliquity or absence of the sun; 2. By the tenuity of the higher atmosphere; 3. By the evaporation which takes place in dry air; and, 4. By the chilling impression shot downwards from a clear and serene sky.

Obliquity of the Sun.

1. In our temperate climates, the thermometer in winter very seldom descends 15 degrees on Fahrenheit's scale, below the point of congelation. But, in the higher latitudes, the intensity of the cold is often far greater. In the northern parts of Sweden and Russia, the rivers and ordinary lakes are frozen to the depth of several feet; wine, and even ardent spirits, become converted into a spongy mass of ice, and, as the cold still augments, it penetrates the living forests, and congeals the very sap of the trees, which occasionally burst from this internal expansion with tremendous noise. The Baltic Sea has been repeatedly covered with a solid floor of ice, capable of transporting whole armies, with all their stores and engines of war. Those waters, indeed, are only brackish; but the more northern ocean itself has often been frozen to a very considerable thickness. In Siberia and Hudson's Bay, and even in the northern provinces of Sweden, mercury has been at some times observed contracted by exposure into a solid semi-metal; and, consequently, the cold which then prevailed must have exceeded 71 degrees, or 39 below the commencement of Fahrenheit's scale.

Elevation of the Place.

2. In elevated tracts the increase of cold is very striking. Even at an altitude of three miles and a half, the air is generally 68 degrees colder than at the level of the sea. On the summit of the Andes, therefore, a thermometer would often sink perhaps under the beginning of Fahrenheit's scale; and it seems probable that mercury would naturally freeze in winter on the top of Mont Blanc. Mountains are hence regarded as the grand stores or depositaries of cold in the milder climates. In every country, therefore, the air of subterraneous caves, and the water of deep springs or wells, are during the summer months comparatively cold. Hence the obvious advantage of cellars, in addition to their preserving an uniform temperature, which is so favourable to the ripening of the liquors deposited in them. But the air at the bottom of an open and very deep pit must be colder than the mean state of the ground, for in all the changes which take place at the surface, the cold air will descend, and the warm air still float over the mouth of the pit. The wealthier classes of antiquity were accustomed, accordingly, to cool the wine for their tables, by suspending it for some time in a bucket let down near the surface of profound wells.

Evaporation.

3. Evaporation is a natural process, by which heat is powerfully abstracted by the exhaling moisture, while this assumes a gaseous constitution in the act of combining with dry air. The fact seems to have been known in the warm regions of the east at a very early period of society, suggested probably by the familiar use of a rude unglazed pottery for all culinary purposes. The Egyptians, and other inhabitants of the sultry shores of the Levant, have, from the remotest ages, cooled the water for drinking in their porous jars. Athenæus reports, from a history of Protagorides, that King Antiochus had always a provision for his table prepared in that way. The water having been carefully decanted from its sediment into earthen pitchers (ὑδρειαις κεραμειαις), these were transported to the highest part of his palace, and exposed to the clear and keen atmosphere (εξαιθριαζουσιν), two boys being appointed to watch them the whole night, and keep constantly wetting their sides. This labour of sprinkling the surface of the jars seems to have been afterwards spared, in consequence probably of the adoption of a more porous kind of earthen-ware. Galen, in his *Commentary on Hippocrates*, relates, that he witnessed the mode of cooling water, which was practised in his time, not only at Alexandria, but over all Egypt. The water, having been previously boiled, was poured at sun-set into shallow pans (αγγοις οστρακινοις), which were then carried to the house-tops, and there exposed during the whole night to the wind; and to preserve the cold thus acquired, the pans were removed at day-break, and placed on the shaded ground, surrounded by leaves of trees, prunings of vines, lettuce, or other slow conducting substances.

The bottles or bags made of goat-skins, in which the wandering Arabs are wont to carry their scanty provision of water, allowing a small portion of the liquid to transude and exhale, render it by consequence comparatively cool, and better fitted to mitigate or allay the intolerable thirst created in traversing their sandy deserts. In Guinea, it is customary to fill gourds or calabashes with water, and suspend them all night from the outer branches of trees.

Cooling Vessels called *Alcarrazas*.

The Moors introduced into Spain a sort of unglazed earthen jugs, named *bucaros* or *alcarrazas*, which, being filled with water, present to the atmosphere a surface constantly humid, and furnish by evaporation, during the dry and hot weather, a refreshing beverage. The same practice has been adopted by degrees in various parts of the south of Europe. In India, during certain months, the apartments are kept comparatively cool, by dashing water against the matting of reeds or bamboos, which line the doors and the outside of the walls. Even the more luxurious mariners, in their voyages between the tropics, are accustomed to cool their wines, by lapping the bottle with wet flannel, and suspending it from the yard or under the cabin-windows. In all such cases, the effect is accelerated, though not augmented, by the swiftness of the current of air. What have been called *Egyptian coolers*, and lately produced by our potters, are less perfect in their operation. Being very thick, they require only to be soaked in water, and the evaporation from their

surface cools the adjacent air. On the inside, however, where the bottle is placed, the action, in consequence of the confined humidity, must be enfeebled. In damp weather, those vessels, it is evident, are entirely useless.

Indian Mode of Collecting Ice.

The natives of India likewise are enabled, by directing a skilful process of evaporation, to procure for themselves a supply of ice during their short winter. In the upper country, not far however from Calcutta, a large open plain being selected, three or four excavations are made in it about thirty feet square and two feet deep, and the bottom covered to the thickness of nearly a foot with sugar canes or dried stalks of Indian corn. On this bed are placed rows of small unglazed earthen pans, about an inch and quarter deep, and extremely porous. In the dusk of the evening, during the months of December, January, and February, these are filled with soft water previously boiled and suffered to cool, when the weather is very fine and clear a great part of the water becomes frozen during the night. The pans are regularly visited at sunrise, and their contents thrown into baskets which retain the ice. These are now carried to a conservatory made by sinking a pit 14 or 15 feet deep, lined with straw under a layer of coarse blanketing. The small sheets of ice are thrown down into the cavity, and rammed into a solid mass. The mouth of the pit is then closed up with straw and blankets, and sheltered by a thatched roof.

Impressions Showered from a Clear Sky.

4. It was stated in the article CLIMATE, that impressions of cold are constantly showered down from a clear and azure sky. These effects are no doubt more conspicuous in the finer regions of the globe. Accordingly, they did not escape the observation of the ancients, but gave rise to opinions which were embodied in the language of poetry. The term Αηϱ was applied only to the grosser part of the atmosphere, while the highest portion of it, free from clouds and vapour, and bordering on the pure fields of æther, received the kindred appellation of Αιθϱια. But this word and its derivatives have always been associated with ideas of *cold*. We have seen that the verb εξαιθϱιαζω is used by Athenæus to signify, the cooling of a body, by exposure under a serene sky. Homer uses the term Αιθϱος, in speaking of the reception of his hero, when overcome with *cold* and toil.* The same poet of nature applies the epithet Αιθϱηγενης or Αιθϱηγενέτης or *frigorific*, to Boreas, the north wind.† The chorus in the *Antigone* of Sophocles deprecates the pelting storm, and likewise the cold (αιθϱια) of inhospitable frozen tracts.‡ The word αιθϱιος is employed by Herodotus to signify a chill as well as a dry atmosphere.|| Of the same import is the expression in Horace—*Sub Jove frigido.*

Their Intensity in the Finer Climates.

In the finer climates, especially, a transpiercing cold is, therefore, felt at night under the clear and sparkling canopy of heaven. The natives carefully avoid exposing themselves to this supposed celestial influence; yet a thin shed of palm leaves may be sufficient at once to screen them from the scorching rays of the sun, and to shelter them against the chilling impressions rained from the higher atmosphere. The captains of the French gallies in the Mediterranean used formerly to cool their wines in summer, by hanging the flasks all night from the masts. At day-break, they were taken down and lapped in several folds of flannel, to preserve them in the same state. The frigorific impression of a serene and azure sky, must undoubtedly have concurred with the power of evaporation, in augmenting the energy of the process of nocturnal cooling, practised anciently in Egypt, and now systematically pursued in the higher grounds of India. As the chillness accumulated on the ground is greatest in clear nights, when the moon shines brightest, it seemed very natural to impute this effect partly to some influence emanating from that feeble luminary. It was long imagined that the lunar beams are essentially cold; and some philosophers, at no remote period, have attempted even to prove the fact by experiment. Mr Boyle, though he rejected judicial astrology, was yet disposed to admit the notion of stellar influences.

Cooling with Snow.

The obvious mode of cooling water, or other liquids, by the infusion of ice or snow, was practised in the warmer countries from the earliest ages. It is even mentioned in the Proverbs of Solomon: "*As the cold of snow in the time of harvest*, so is a faithful messenger to them that send him." Aristotle, presuming that the finer parts of water are dissipated by congelation, maintained that it is pernicious to drink melted snow. This speculative opinion seems not, however, to have been regarded by the ancients. Theocritus calls snow-water an *ambrosial drink*,—ποτος αμβϱοσιος. Xenophon mentions the practice of cooling wine, by the addition of snow. It is related by the historians of Alexander the Great, that, in his Indian expedition, when he laid siege to the city of Petra, he commanded thirty pits to be dug and filled with snow, which was covered over with oak branches. The luxurious Romans had excavations regularly formed for keeping snow the whole year, chaff and other light substances being employed to preclude from it the access of heat. But, as the snow, preserved in this way, could not escape being soiled, instead of mixing it directly in the drinking cup, a more refined practice was introduced, of surrounding the silver goblet which contained the liquor with a mass of the melting snow. This improvement was ascribed to the profligate emperor Nero. Similar modes of storing up

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* Αἴθϱῳ και καμάτῳ δεδμημένον ἦγεν ἐς οἶκον.
Odyss. Lib. XIV. 318.

† Ὡς δ' ὅτε ταϱφειαὶ νιφάδες Διὸς ἐκποτέονται,
Ψυχϱαὶ ὑπαὶ ϱιπῆς αἰθϱηγενέος Βοϱέαο.
Iliad. Lib. XIX. 357-8.
Καὶ Βοϱέης αἰθϱηγενέτης, μέγα κῦμα κυλινδων. *Odyss.* Lib. V. 296.

‡ δυσαύλων πάγων ἄιθϱια
κὰι δυσομβϱα φευγειν βέλη. *Antigone*, 357.

|| Θεϱμότεϱον γαϱ δη εϛι το ὑδωϱ τῆς τε αιθϱιας και τῆς δϱοσου.
Euterpe.

snow have been adopted in all the warm countries. The caves on the sides of Mount Ætna are considered as natural magazines, for supplying a material which is not only carried down to Palermo and Messina, but even shipped to the island of Malta. The Italians formerly cooled their wine, by setting the large glass flasks containing it, in wide vessels of wood or cork, the intervening space being filled with snow, on which water was poured.

Cooling with Nitre.

Saltpetre or nitre being almost a natural production of the east, its property of rendering water cold by solution, was probably known, from a very remote period, to the oriental nations. This process of cooling is described in the *Institutes* of Akbar as the discovery of that enlightened prince, who governed India with parental mildness, from the year 1560 to 1605. One part of nitre is directed to be thrown into a vessel containing two parts of water, and a gugglet of pewter or silver filled with pure water, and having its mouth close stopped, is then stirred quickly in the mixture for the space of a quarter of an hour.

Introduced to Italy.

The frigorific property of nitre was probably first communicated from India or Persia to Europe, and seems to have become known to the Italians about the middle of the sixteenth century. As early as the year 1550, all the rich families in Rome cooled the liquors for their tables, by dissolving that salt in water. Into a vessel of cold water, the nitre was gradually added in the proportion of a fourth or fifth part, while a globular bottle, with a long neck, containing the wine or water to be cooled, was whirled rapidly round its axis. The salt, being afterwards recovered by crystallization, would always serve the same purpose again, with undiminished effect. In India, every family of distinction keeps a domestic, whose sole employment is to cool liquors by this process; but nitre being cheap in that country, it is used in larger proportions, and the water charged with it is allowed to become a perquisite of the operator.

Cooling by Saline Powders.

The application of salts to produce cold was extended by Boyle, and afterwards more successively by Fahrenheit. But, within these twenty years, Mr Walker of Oxford, and Professor Lowitz of St Petersburg, have resumed the subject, and produced compound saline powders, possessed of intense frigorific power. The solution of salts in water, expanding that liquid, augments its capacity for heat, and consequently depresses its temperature. This effect is likewise the greater, in proportion to the quantity of saline matter which can be dissolved. But after water is saturated with one species of salt, it can still absorb some portion of another. Hence the frigorific effects of solution are always increased, by employing a compound dry powder. Nitre and sal-ammoniac, or the nitrate of potash and the muriate of soda in equal parts, added in the form of a dry powder to three parts by weight of water, will sink Fahrenheit's thermometer 40 degrees. But equal parts of the muriate of ammonia and of the nitrate of potash, with one part and a half of the sulphate of soda or common Glauber's salt, will cool down three parts of water 46 degrees. A still greater effect, amounting to 57 degrees, is produced, by dissolving equal parts of the nitrate of ammonia and of the carbonate of soda, in one part of water. The frigorific action is in general augmented, by throwing the desiccated powder into dilute acid instead of water. Thus, three parts of the phosphate of soda and two parts of the nitrate of ammonia joined to rather more than one part of weak nitric acid, will sink the thermometer 71 degrees.

Principle of Evaporation.

These changes induced on the temperature of the liquid menstruum are, no doubt, considerable, yet they are still only transient, and the process requires some address and manipulation, not always readily attained. But the principle of evaporation, when rightly understood, leads to a far easier mode of cooling liquids, which may be prolonged at pleasure. A close investigation of that principle, at the very commencement of his philosophical labours, has conducted Professor Leslie through the whole train of his discoveries on the subject of refrigeration. The process of evaporation had not then been examined with attention. The depression of temperature which always accompanies it, was hastily supposed to be proportional to the rate with which the moisture is dissipated, and to be therefore augmented by every circumstance that can accelerate this effect. If water, contained in a porous vessel, expose on all sides its surface to a current of air, it will cool down to a certain point, and there its temperature will remain stationary. The rapidity of the current must, no doubt, hasten the period of equilibrium, but the degree of cold thus induced will be still the same. A little reflection may discover how this happens. Though the humid surface has ceased to grow colder, the dispersion of invisible vapour, and the corresponding abstraction of heat, still continues without intermission. The same medium, therefore, which transports the vapour, must also furnish the portion of heat required for its incessant formation. In fact, after the water has been once cooled down, each portion of the ambient air which comes to touch the evaporating surface must, from its contact with a substance so greatly denser than itself, be likewise cooled to the same standard, and must hence communicate to the liquid its surplus share of heat, or the difference between the prior and the subsequent state of the solvent, which is proportional to the diminution of temperature it has suffered. Every shell of air which encircles in succession the humid mass, while it absorbs, along with the moisture which it dissolves, the measure of heat necessary to convert this into steam, does, at the same instant, thus deposit an equal measure of its own heat, on the chill exhaling surface. The abstraction of heat by vaporization on the one hand, and, on the other, its deposition at the surface of contact, are, therefore, opposite contemporaneous acts, which soon produce a mutual balance, and thereafter the temperature induced continues without the smallest alteration. A rapid circulation of the evaporating medium may quicken the operation of those causes; but, so long as it possesses the same drying quality, it cannot, in any degree, derange the resulting temperature. The

heat deposited by the air on the humid surface becomes thus an accurate measure of the heat spent in vaporizing the portion of moisture required for the saturation of that solvent at its lowered temperature. The dryness of the air is therefore, under all circumstances, precisely indicated, by the depression of temperature produced on a humid surface which has been exposed freely to its action.

Hygrometer.

Guided by these views, Mr Leslie was enabled to construct a correct *Hygrometer* that should indicate the *dryness* of the air, from the diminution of temperature which a small body of water, exposed on all sides, suffers by evaporation. His efforts again to improve this instrument, led him next to the invention of the *Differential Thermometer*, which was converted into an hygrometer, by having one of its balls covered with cambric, lint or tissue paper, capable of being easily wetted. Reduced to such a delicate and commodious form, it detected, with the utmost precision, and under all circumstances, the relative condition of the air in regard to dryness.

Cooling Effected by the Presence of Absorbents.

It appears that absorbent substances, exposing a broad surface, are capable of assimilating to their previous state the air confined over them. Flannel, for instance, which has been intensely dried, will support a remarkable degree of dryness in a close receiver. The trap-rock and compound clays, brayed into a coarse powder, and desiccated before a strong fire, will exert a more powerful and extended action. But dried oat-meal will act with equal energy, and for a longer time. Of the saline substances, the muriate of lime absorbs moisture with the greatest and most protracted force. After it has become drenched with humidity, it may likewise be recovered again, though the process of restoring it unaltered is rather troublesome. But the best and most powerful absorbent is the concentrated sulphuric acid, or the oil of vitriol of commerce, which continues for a long time to attract moisture with almost undiminished force, and possesses, besides, the valuable property, after it has become charged with humidity, of being easily restored again, by the application of heat, to its original strength.

Mode of Proceeding.

To cool water, in any climate or state of the atmosphere, we have only therefore to put it into a small porous vessel, presenting on all sides a humid surface, and to suspend this within a close wide cistern, of which the bottom is covered with a layer of sulphuric acid. The broad surface of the acid, absorbing the moisture as fast as it diffuses itself through the confined air, keeps that medium constantly at a point of extreme dryness, and thus enables it to support, with undiminished vigour, the process of evaporation.

In practice, the cistern or refrigeratory, having a broad cylindrical form, from twelve to sixteen inches in diameter, and composed of dense well-glazed earthenware (See Plate LXV. fig. 7.), is placed in a cellar or other cool place, and charged with sulphuric acid to the height of about half an inch from the bottom. One of the porous earthen pots, being filled up to the lip with water fresh drawn from the well, is set upon a low porcelain stand in the middle of the cistern, to which the lid or cover is then carefully adapted. In the space of from three to perhaps five hours, the cooling is nearly completed, and the pot should now be removed: for though the water will be kept at the same degree of coldness as long as it remains shut up within the refrigeratory, the acid would be unnecessarily weakened by the incessant absorption of moisture.

Extent of this Power.

The production of cold is greater when the cistern is large, or when a small pot is used, insomuch that the effect will be diminished one half, if the humid surface should equal that of the acid, the opposite actions of such surfaces inducing an exactly intermediate state, with respect to dryness and moisture, in the condition of the aërial medium. The power of evaporation is also diminished in the low temperatures. Thus, if the atmosphere were at 95°, by Fahrenheit, the water within the refrigeratory might be cooled down 36°, or brought to 59°; but if the thermometer be at 50° the water can be cooled only 18°, which brings it to the freezing point. This seems to be a very convenient property, since the power of the refrigeratory is always the greatest at the season when its application is most wanted.

It is easy, therefore, by such means, to cool water in our climate at all times, to near the freezing point, and, even under the torrid zone, to reduce it to the temperature of 60 degrees, which, in those regions, is sufficient perhaps for essential comfort.

By supplying a succession of porous earthen pots, the acid will continue to act with scarcely diminished force, till it has absorbed half its weight of moisture; during which time it will have assisted in cooling about fifty times that quantity of the water exposed to evaporation. At this stage, the dilute acid should be drawn off, and a charge of concentrated acid again introduced into the refrigeratory.

Its Use for Domestic Purposes.

This method of procuring cold, it will readily be perceived, could be employed with advantage for various domestic purposes. For instance, butter may in summer be kept cool for the table, by putting it, after being washed with water, into a wet porous pot, and shutting this up for a couple of hours in the refrigeratory. To cool wine sufficiently, one bottle only is used at a time in the smallest refrigeratory: A sheath of stocking or flannel previously soaked in water being drawn over the body of the bottle, it is laid in a reclined position on one of the porcelain sliders, near the surface of the acid, and allowed to remain shut up during the space of three or four hours.

The refrigerating combination here employed produces its effect, by a sort of invisible distillation carried on by the play and circulation of the included air. The minute portions of moisture which successively combine with the contiguous medium, must abstract from the mass of water as much heat as would support them in the state of vapour, or would in ordinary cases convert them into steam. This vapour again, being conveyed through the air, is attracted by the sulphuric acid, and, recovering its liquid constitution, deposits the heat which it had borne away. The acid is therefore warmed at the expence of the water subjected to evaporation, and the whole performance of the apparatus consists in a mere transfer and interchange of condition.

CONGELATION

Congelation. Is the passage of any substance from the liquid to a solid form, in consequence of the abstraction of heat. The conversion of water into ice could not fail to draw the notice of men in all ages. The minute and divided fragments of the same production, which descend from the clouds in the shape of snow or hail, displayed the various powers of nature. The ancients imagined, that water which has lain for ages in a frozen state acquires at last a permanent consolidation. They extended, accordingly, the name of ice (κρυσταλλος or *crystal*) to the pure and pellucid kind of quartz, which often occurs on the sides of lofty mountains, near the boundary of perpetual congelation.

Water loses its Air in the act of Freezing.

It was early remarked that melted ice has the lightness and quality of boiled water. In fact, the portion of air combined with ordinary water is discharged in the act of freezing as well as in that of boiling. Water thus deprived of its air, is therefore prepared for a readier congelation. The ancients accordingly, we have seen, always boiled the water which they designed afterwards to cool. Aristotle relates in his *Meteorology*, that the fishermen who cast their nets in the Pontine Lake, used to carry in close vessels boiled water, for the purpose of sprinkling the reeds, that these might quickly freeze together, and cease to disturb the fish by their rustling noise. The expulsion of air from water during the progress of congelation, was afterwards fully proved by Mariotte, one of the earliest members of the French Academy of Sciences. If two wine glasses, filled, the one with water from the well, and the other with water recently boiled, be exposed to the frost, the ice of the latter will seem almost uniformly pellucid, while the ice of the former will appear charged with small air-bubbles crowding towards the centre of the mass, to which they are driven by the advance of the congelation.

That congelation shoots at angles of 120 degrees, was first observed in the beginning of the seventeenth century by the great Kepler; and this ardent and inventive genius, in an elaborate Dissertation, which he printed as a New Year's present, investigated the various forms and modifications of the icy crystals. The subject was next discussed by Des Cartes and Bartholinus, and about a century afterwards resumed by Mairan, and may be considered as a step towards the general theory of crystallography, which has been since reared by the patience and ingenuity of Häuy.

Imperfect Congelation.

Other liquids, such as vinegar, dilute mineral acids, weak spirits, and saline solutions, are likewise capable of being frozen; but they yield an ice distinctly different from that of pure water, resembling an aggregation rather than an uniform solid, and wanting consistency, strength, and clearness. The frost appears to seize on the water only, and to fill the compound liquid with close spicular shoots, entangling the stronger acid or brine in their interstices. It was a mistake, therefore, to assert that the ice of sea-water is really fresh. In the process of melting, some portion of the brine may probably flow off, but the residue still is always brackish. This fact is even positively stated by the missionary Crantz, in his accurate account of Greenland. The very intelligent and enterprising navigator, Mr Scoresby, reckons the specific gravity of the spongy salt-water ice to be .873, while that of fresh-water ice amounted to .937.

Artificial Congelation discovered in Italy;

The ancients were altogether unacquainted with artificial congelation, and with any cold, indeed, below that of freezing. The application of nitre to the cooling of water seems, before the close of the sixteenth century, to have suggested to the Italians the experiment of mixing it with snow. A very intense degree of cold was thus generated, capable of converting speedily into solid ice a body of water contained in a smaller vessel immersed in the dissolving mixture. Sanctorio, who may be regarded as the father of modern physics, mentions, in his *Commentary on Avicenna*, that he produced the same effect, by employing common salt instead of nitre, in the proportion of the third part of the snow, and had repeatedly performed the experiment in the presence of a numerous auditory.

and gradually communicated to the rest of Europe.

From Italy, this discovery was gradually communicated over the rest of Europe. In the course of the seventeenth century, iced creams, fruits, and various confitures, were first produced on the tables of the luxurious. The famous coffee-house, *Procope*, was founded at Paris in 1660, by a Florentine of that name, a vender of lemonade, who was very successful in the art of preparing rich ices. Thirty years afterwards, the use of such artificial delicacies in that city had become quite common.

Rendered more Intense.

The cold resulting from the addition of saline powders to snow or pounded ice, depends on the powerful attraction of those salts which restores the frozen mass to its liquid form, and therefore augments its capacity for heat. Fahrenheit fixed the commencement of his thermometrical scale at the temperature of the compound of salt and snow, conceiving it to be the lowest possible. But much lower degrees of cold are now produced. One part of the muriate of soda, or purified common salt, being added to two parts of dry snow or pounded ice, will sink the thermometer five degrees below zero. One part of sal-ammoniac, and two of common salt, joined to five parts of snow, will bring it seven degrees lower. But equal parts of the nitrate of ammonia and common salt, joined to two parts and a half of snow, will depress the thermometer 25 degrees below the freezing point.

Still more intense cold might be produced, if the ingredients were, before their mixture, cooled down to congelation. Thus, five parts of the muriate of lime, added to four parts of snow, will sink the thermometer to 40 degrees below the beginning of the scale, or the limit of freezing mercury; and, if the muriate of lime were crystallized, the effect would be 10 degrees more. The same extreme energy is exerted, on adding four parts of dry caustic potash to three parts of snow.

Cold.

The mineral acids likewise, in a diluted state, produce similar effects. Two parts of weak sulphuric acid, joined to three of snow, will sink the thermometer to 23 degrees below zero. The muriatic and nitric acids, in nearly the same proportions, will depress it from 4 to 7 degrees more. By repeating the applications, therefore, a most intense cold may be created. Yet, to succeed completely, a skilful manipulation is required. The saline matters should be reduced to a fine powder, and the freezing mixtures should be made in very thin vessels, not larger than will barely hold them. In this way, by successive stages of cooling, Mr Walker once obtained the enormous cold of 91 degrees below the commencement of Fahrenheit's scale.

The mere evaporation of some very volatile liquids is sufficient to produce excessive cold. Thus, if a thermometer, having its bulb covered with lint, be dipped in the common or sulphuric ether, it will, on exposure to the air, sink perhaps 30 or 40 degrees. This effect is augmented under the receiver of an air-pump. If a narrow thin tube of glass, filled with water, and cased on the outside with lint soaked in æther, be suspended above the pump, and the exhaustion quickly made, a cylinder of ice will be formed.

The same property is manifested in a higher degree by a singular liquid, discovered by Lampadius in 1796, by distilling a mixture of pyrites and charcoal. It was called at first the *alcohol of sulphur*, but now more appropriately the *sulphuret of carbon*. According to Dr Marcet, who has completed the investigation of its properties, a thermometer having its bulb covered with lint wetted by this liquid, and held in the open air, will sink not fewer than 60 degrees. But if the same experiment be performed within the exhausted receiver of an air-pump, the alcohol of the barometer will even descend to 82 degrees below zero. It must be observed, however, that these effects produced by the evaporation of æther, and of the sulphuret of carbon, are quite evanescent, and that the receiver becomes soon charged with their fumes, which then prevent any farther action. Those fumes likewise corrode the valves of the pump, and soon render it quite useless. Neither æther, therefore, nor the sulphuret of carbon, could be applied in practice with any sort of advantage, to the production of ice, even on the smallest scale.

New Mode of Artificial Congelation.

We have now to relate a discovery which will enable human skill to command the refrigerating powers of nature; and, by the help of an adequate machinery, to create cold and produce ice, on a large scale, at all seasons, and in the hottest climates of the globe. But, to explain this interesting subject with greater clearness and accuracy, it is requisite to trace the successive advances which conducted to the result. Where a conclusion appears simple, the careless observer is apt to suppose it easily attained; yet, though sound philosophy tends always to simplification, the rare quality of simplicity is scarcely ever the flash of intuition, but the slow fruit of close and patient investigation.

In pursuing the researches with his hygrometer, Professor Leslie was early induced to inquire into the condition of the higher atmosphere, and its relations to humidity. He thus detected a fact of great importance in meteorology, and pointing at various ulterior views.

Investigation of its Principles.

As rarefaction enlarges the capacity of air for heat, so it likewise augments the disposition to hold moisture; at the same time, that the removal of the ordinary pressure facilitates the expansion of the liquid matter, and its conversion into a gaseous form. Accordingly, if the hygrometer be suspended within a large receiver, from which a certain portion of air is quickly abstracted, it will sink with rapidity. In summer, the additional dryness thus produced amounts to about 50 hygrometric degrees, each time the air has its rarefaction doubled; so that, supposing the operation of exhausting to be performed with expedition, and the residuum reduced to a sixty-fourth part, the hygrometer would mark a descent of 300^0. But this effect is only momentary, for the thin air very soon becomes charged with moisture, and, consequently, ceases to act on the wet ball of the hygrometer. The cold, however, excited on the surface of that ball, by such intense evaporation, will have previously frozen the coating.

The increased power of aqueous solution which air acquires as it grows thinner, being ascertained and carefully investigated, the object was to combine the action of absorbent with the transient dryness produced within a receiver by rarefaction. The sentient ball of the hygrometer being covered with dry salt of tartar, the instrument first indicated increasing dryness, and afterwards, as the rarefaction proceeded, it changed its course, and marked humidity. The same variation of effect nearly was observed, when the hygrometer had been wetted as usual with pure water, and a broad saucer containing the mild vegetable alkali was placed on the plate of the air-pump. It was thus proved, that the action of this imperfect absorbent is soon overpowered by the tendency to vaporization in attenuated air, and that, beyond a certain limit, it surrenders its latent moisture.

Mr Leslie resolved, therefore, to try the effect of sulphuric acid, whose peculiar energy as an absorbent he had, under other circumstances, already ascertained. But various incidents prevented him, for a considerable time, from resuming his philosophical inquiries. At last he began those projected experiments, and was almost immediately rewarded by the disclosure of a property, the application of which blazed on his fancy. In the month of June 1810, having introduced a surface of sulphuric acid under the receiver of an air-pump, he perceived with pleasure that this substance only superadded its peculiar attraction for moisture, to the ordinary effects resulting from the progress of exhaustion; and, what was still more important, that it continued to support, with undiminished energy, the dryness thus created. The attenuated air was not suffered, as before, to grow charged with humidity; but each portion of that medium, as fast as it became saturated by touching the wet ball of the hygrometer, transported its vapour to the acid, and was thence sent back denuded of the load, and fitted again to renew its attack with fresh vigour. By this perpetual circulation, therefore, between the exhaling and the absorbing surface, the diffuse residuum of air

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is maintained constantly at the same state of dryness. The sentient ball of the hygrometer, which had been covered with several folds of wetted tissue paper, was observed, at an early stage of the operation, suddenly to lose its blue tint and assume a dull white, while the coloured liquor sprung upwards in the stem, where it continued, for the space of a minute, stationary, and again slowly subsided. The act of congelation had, therefore, at this moment taken place, and the paper remained frozen several minutes, till its congealed moisture was entirely dispersed. Pursuing this decisive intimation, the hygrometer was removed, and a watch-glass filled with water substituted in its place. By a few strokes of the pump, the whole was converted into a solid cake of ice, which, being left in the rare medium, continued to evaporate, and, after the interval of perhaps an hour, totally disappeared. A small cup for holding the water was next adopted, and the whole apparatus gradually enlarged.

Efficient Power nearly the same at all Temperatures.

The powers, both of vaporization and of absorption, being greatly augmented in the higher temperatures, the same limit of cold nearly is in all cases attained, by a certain measure of exhaustion. When the air has been rarefied 250 times, the utmost that, under such circumstances, can perhaps be effected, the surface of evaporation is cooled down 120 degrees of Fahrenheit in winter, and would probably sink near 200 in summer. Nay, a far less tenuity of the medium, when combined with the action of sulphuric acid, is capable of producing and supporting a very intense cold. If the air be rarefied only 50 times, a depression of temperature will be produced, amounting to 80 or even 100 degrees of Fahrenheit's scale.

Mode of Proceeding.

We are thus enabled, in the hottest weather, to freeze a mass of water, and to keep it frozen, till it gradually wastes away, by a continued but invisible process of evaporation. The only thing required is, that the surface of the acid should approach tolerably near to that of the water, and should have a greater extent, for otherwise the moisture would exhale more copiously than it could be transferred and absorbed, and, consequently, the dryness of the rarefied medium would become reduced, and its evaporating energy essentially impaired. The acid should be poured to the depth perhaps of half an inch in a broad flat dish, which is covered by a receiver of a form nearly hemispherical; the water exposed to congelation may be contained in a shallow cup, about half the width of the dish, and having its rim supported by a narrow porcelain ring upheld above the surface of the acid by three slender feet. (*See fig.* 1 and 2. Plate LXV.) It is of consequence that the water should be insulated as much as possible, or should present only a humid surface to the contact of the surrounding medium, for the dry sides of the cup might receive, from communication with the external air, such accessions of heat, as greatly to diminish, if not to counteract the refrigerating effects of evaporation. This inconvenience, however, is in a great measure obviated, by investing the cup with an outer case at the interval of about half an inch. If both the cup and its case consist of glass, the process of congelation is viewed most completely; yet when they are formed of a bright metal, the effect appears on the whole more striking. But the preferable mode, and that which prevents any waste of the powers of refrigeration, is to expose the water in a pan of porous earthen-ware. If common water be used it will evolve air bubbles very copiously as the exhaustion proceeds; in a few minutes, and long before the limit of rarefaction has been attained, the icy spiculæ will shoot beautifully through the liquid mass, and entwine it with a reticulated contexture. As the process of congelation goes forward, a new discharge of air from the substance of the water takes place, and marks the regular advances of consolidation. But after the water has all become solid ice, which, unless it exceed the depth of an inch, may generally be effected in less than half an hour, the circle of evaporation and subsequent absorption is still maintained. A minute film of ice, abstracting from the internal mass a redoubled share of heat, passes, by invisible transitions, successively into the state of water and of steam, which, dissolving in the thin ambient air, is conveyed to the acid, where it again assumes the liquid form, and, in the act of combination, likewise surrenders its heat.

Moderate Rarefaction sufficient to maintain the Ice.

In performing this experiment, the object is generally to seek at first to push the rarefaction as far as the circumstances will admit. But the disposition of the water to fill the receiver with vapour, being only in part subdued by the action of the sulphuric acid, a limit is soon opposed to the progress of exhaustion, and the included air can seldom be rarefied above a hundred times, or till its elasticity can support no more than a column of mercury about three tenths of an inch in height. A smaller rarefaction, perhaps from ten times to twenty times, will be found sufficient to support congelation after it has once taken place. The ice then becomes rounded by degrees at the edges, and wastes away insensibly, its surface being incessantly corroded by the play of the ambient air, and the minute exhalations conveyed by an invisible process to the sulphuric acid, which, from its absorbing the vapour, is all the time maintained above the temperature of the apartment. The ice, kept in this way, suffers a very slow consumption; for a lump of it, about a pound in weight and two inches thick, is sometimes not entirely gone in the space of eight or ten days. During the whole progress of its wasting, the ice still commonly retains an uniform transparent consistence; but, in a more advanced stage, it occasionally betrays a sort of honey-combed appearance, owing to the minute cavities formed by globules of air, set loose in the act of freezing, yet entangled in the mass, and which are afterwards enlarged by the erosion of the solvent medium.

But almost every practical object is attained, through far inferior powers of refrigeration. Water is the most easily frozen, by leaving it, perhaps for the space of an hour, to the slow action of air that has been rarefied only in a very moderate degree. This process meets with less impediment, and the ice formed by it appears likewise more compact, when the water has been already purged of the greater part of its combined air, either by distillation or by long continued boiling. The water which has undergone such operation, should be introduced as

quickly as possible into a decanter, and filled up close to the stopper, else it will attract air most greedily, and return nearly to its former state in the course of a few hours.

Elegant Mode of Freezing.

The most elegant and instructive mode of effecting artificial congelation, is to perform the process under the transferrer of an air-pump. A thick but clear glass cup being selected, of about two or three inches in diameter, has its lips ground flat, and covered occasionally, though not absolutely shut, with a broad circular lid of plate glass, which is suspended horizontally from a rod passing through a collar of leather. (*See fig.* 6. Plate LXV.) This cup is nearly filled with fresh distilled water, and supported by a slender metallic ring, with glass feet, about an inch above the surface of a body of sulphuric acid, perhaps three quarters of an inch in thickness, and occupying the bottom of a deep glass bason that has a diameter of nearly seven inches. In this state, the receiver being adapted, and the lid pressed down to cover the mouth of the cup, the transferrer is screwed to the air-pump, and the rarefaction, under those circumstances, pushed so far as to leave only about the hundred and fiftieth part of a residuum; and the cock being turned to secure that exhaustion, the compound apparatus is then detached from the pump, and removed to some convenient apartment. As long as the cup is covered, the water will remain quite unaltered; but, on drawing up the rod half an inch or more, to admit the play of the rare medium, a bundle of spicular ice will, after the lapse perhaps of five minutes, dart suddenly through the whole of the liquid mass; and the consolidation will afterwards descend regularly, thickening the horizontal stratum by insensible gradations, and forming in its progress a beautiful transparent cake. On letting down the cover again, the process of evaporation being now checked or almost entirely stopped, the ice returns slowly into its former liquid condition. In this way, the same portion of water may, even at distant intervals of time, be repeatedly congealed and thawed successively twenty or thirty times. During the first operations of freezing, some air is liberated; but this extrication diminishes at each subsequent act, and the ice, free from the smallest specks, resembles a piece of the purest crystal.

Progress of Congelation.

This artificial freezing of water in a cup of glass or metal, affords the best opportunity of examining the progress of crystallization. The appearance presented, however, is extremely various. When the frigorific action is most intense, the congelation sweeps at once over the whole surface of the water, obscuring it like a cloud. But, in general, the process advances more slowly; bundles of spiculæ, from different points, sometimes from the centre, though commonly from the sides of the cup, stretching out and spreading by degrees with a sort of feathered texture. (*See fig.* 4.) By this combined operation, the surface of the water soon becomes an uniform sheet of ice. Yet the effect is at times singularly varied; the spicular shoots, advancing in different directions, come to inclose, near the middle of the cup, a rectilineal space, which, by unequal though continued encroachment, is reduced to a triangle; and the mass below, being partly frozen, and therefore expanded, the water is gradually squeezed up through the orifice, and forms by congelation a regular pyramid, rising by successive steps; or, if the projecting force be greater, and the hole more contracted, it will dart off like a pillar. The radiating or feathered lines which at first mark the frozen surface, are only the edges of very thin plates of ice, implanted at determinate angles, but each parcel composed of parallel planes. This internal formation appears very conspicuous in the congealed mass which has been removed from a metallic cup, before it is entirely consolidated.—Sea-water will freeze with almost equal ease, but it forms an incompact ice like congealed syrup, or what is commonly called *water-ice*.

When cups of glass or metal are used, the cold excited at the open surface of the liquid extends its influence gradually downwards. But if the water be exposed in a porous vessel, the process of evaporation, then taking effect on all sides, proceeds with a nearly regular consolidation towards the centre of the mass, thickening rather faster at the bottom from its proximity to the action of the absorbent, and leaving sometimes a reticulated space near the middle of the upper surface, through which the air, disengaged by the progress of congelation, makes its escape.

Singular Modification of the Process.

When very feeble powers of refrigeration are employed, a most singular and beautiful appearance is, in course of time, slowly produced. If a pan of porous earthen-ware, from four to six inches wide, be filled to the utmost with common water till it rise above the lips, and planted above a dish of ten or twelve inches diameter, containing a body of sulphuric acid, and then a broad round receiver placed over it; on reducing the included air to some limit between the twentieth and the fifth part of its usual density, according to the coldness of the apartment, the liquid mass will, in the space of an hour or two, become entwined with icy shoots, which gradually enlarge and acquire more solidity, but always leave the fabric loose and unfrozen below. The icy crust which covers the rim, now receiving continual accessions from beneath, rises perpendicularly by insensible degrees. From each point on the rough surface of the vessel, filaments of ice, like bundles of spun glass, are protruded, fed by the humidity conveyed through its substance, and forming in their aggregation a fine silvery surface, analogous to that of fibrous gypsum or satin-spar. At the same time, another similar growth, though of less extent, takes place on the under side of the pan, so that continuous icy threads might appear vertically to transpierce the ware. The whole of the bottom becomes likewise covered over with elegant icy foliations. (*See fig.* 5.) Twenty or thirty hours may be required to produce those singular effects; but the upper body of ice continues to rise for the space of several days, till it forms a circular wall of near three inches in height, leaving an interior grotto lined with fantastic groupes of icicles. In the meanwhile, the exfoliations have disappeared from the under side, and the outer incrustation is reduced, by the absorbing process, to a narrow ring. The icy wall now suffers a regular waste from external erosion, and its fibrous structure becomes rounded and less apparent. Of its altitude, however, it loses but little for some time; and even a deposition of congealed films along its coping or upper edge, seems to take place, at a certain stage of the process.

Cold.

This curious effect is owing to a circumstance, which as it serves to explain some of the grand productions of nature, particularly the *Icebergs* of the Arctic Circle, merits particular attention. The circular margin of the ice, being nearer the action of the sulphuric acid than its inner cavity, must suffer, by direct evaporation, a greater loss of heat; and, consequently, each portion of thin air that rises from the low cavity, being chilled in passing over the colder ledge, must deposite a minute corresponding share of its moisture, which instantly attaches itself and incrusts the ring. Whatever inequalities existed at first in the surface of the ice, will hence continually increase.

Artificial Congelation best performed on a large Scale.

Artificial congelation is always most commodiously performed on a large scale. Since the extreme of rarefaction is not wanted, the air-pump employed in the process admits of being considerably simplified, and rendered vastly more expeditious in its operation: Two or three minutes at most will be sufficient for procuring the degree of exhaustion required, and the combined powers of evaporation and absorption will afterwards gradually produce their capital effect. In general, plates of about a foot in diameter should be preferred, which can be connected at pleasure with the main body of the pump. The dish holding the sulphuric acid is nearly as wide as the flat receiver; and a set of evaporating pans belongs to it, of different sizes, from seven to three inches in diameter, which are severally to be used according to circumstances. The largest pan is employed in the cold season, and the smaller ones may be successively taken as the season becomes sultry. On the whole, it is better not to overstrain the operation, and rather to divide the water under different receivers, if unusual powers of refrigeration should be required. As soon as the air is partly extracted from one receiver, the communication is immediately stopped with the barrel of the pump, and the process of exhaustion is repeated on another. In this way, any number of receivers, it is evident, may be connected with the same machine. If we suppose but six of these to be used, the labour of a quarter of an hour will set as many evaporating pans in full action, and may, therefore, in less than an hour afterwards produce nearly six pounds of solid ice. The waste which the water sustains during this conversion is extremely small, seldom indeed amounting to the fiftieth part of the whole. Nor, till after multiplied repetitions, is the action of the sulphuric acid considerably enfeebled by its aqueous absorption. At first that diminution is hardly perceptible, not being the hundredth part when the acid has acquired as much as the tenth of its weight of water. But such influence gains rapidly, and rises with accelerated progression. When the quantity of moisture absorbed amounts to the fourth part by weight of the acid, the power of supporting cold is diminished by a twentieth; and, after the weights of both these come to be equal, the refrigerating energy is reduced to less than the half. Sulphuric acid is hence capable of effecting the congelation of more than twenty times its weight of water, before it has imbibed near an equal bulk of that liquid, or has lost about the eighth part of its refrigerating power. The acid should then be removed, and concentrated anew by slow distillation.

Congelation might be connected with the Steam-Engine.

When the exhaling and absorbing surfaces are rightly disposed and apportioned, the moderate rarefaction, from twenty to forty times, which is adequate to the freezing of water, may be readily procured by the condensation of steam. In all manufactures where the steam-engine is employed, ice may, therefore, at all times be formed in any quantity, and with very little additional expence. It is only required to bring a narrow pipe from the condensing vessel, and to direct it along a range of receivers, under each of which the water and the acid are severally placed. These receivers, with which the pipe communicates by distinct apertures, may, for the sake of economy, be constructed of cast-iron, and adapted with hinges to the rim of a broad shallow dish of the same metal, but lined with lead to hold the acid.

Congelation of Mercury.

The combined powers of rarefaction and absorption are capable of generating much greater effects than the mere freezing of water. Such frigorific energy, however, is at all times sufficient for effecting the congelation of mercury. Accordingly, if mercury, contained in a hollow pear-shaped piece of ice, be suspended by cross threads near a broad surface of sulphuric acid under a receiver; on urging the rarefaction, it will become frozen, and may remain in that solid state for the space of several hours. But this very striking experiment is easily performed without any foreign aid. Having introduced mercury into the large bulb of a thermometer, and attached the tube to the rod of a transferrer, let this be placed over the wide dish containing sulphuric acid, in the midst of which is planted a very small tumbler nearly filled with water: After the included air has been rarefied about fifty times, let the bulb be dipped repeatedly into the very cold but unfrozen water, and again drawn up about an inch; in this way, it will become incrusted with successive coats of ice, to the thickness perhaps of the twentieth part of an inch: The water being now removed, the pendant icicle cut away from the bulb, and its surface smoothed by the touch of a warm finger, the transferrer is again replaced, the bulb let down within half an inch of the acid, and the exhaustion pushed to the utmost: When the syphon-gage has come to stand under the tenth of an inch, the icy crust starts into divided fissures, and the mercury, having gradually descended in the tube till it reach its point of congelation, or 39 degrees below zero, sinks by a sudden contraction almost into the cavity of the bulb; and the apparatus being then removed and the ball broken, the metal appears a solid shining mass, that will bear the stroke of a hammer.

Still greater Cold created.

But a still greater degree of cold may be created, by applying the same process likewise to cool the atmosphere which encircles the apparatus itself. A glass mattrass was blown nearly of a hemispherical shape, its bottom quite flat, and about three inches in diameter, and its neck about half an inch wide and cut square over: The whole was covered with a coat of patent lint, which takes up water very copiously, a portion of sulphuric acid was next introduced, forming a layer of perhaps a quarter of an inch thick, and a spirit of wine thermometer, having its bulb also cased with wetted lint, was then inserted within the mattrass, a brass ring attached to the tube securing it in the

Cold.

right position. Things being thus arranged, the mattrass or flat bottle, with its thermometer, was placed on a slender stool with glass feet, about an inch above the sulphuric acid in the broad bason, and the large receiver luted over it. The air was then partly extracted, till the gage came below one inch: In a few minutes, the lint was frozen entirely, and looked white. After an interval of a quarter of an hour, to allow time for the evaporation of that icy coat to cool down the interior apparatus, the pump was again urged, and the exhaustion pushed to about three-tenths of an inch. In a short while, the inclosed thermometer sunk not fewer than 180 degrees, and remained stationary, till the ice had wasted away.

It is obvious, therefore, that the refrigerating powers could be pushed still farther by a judicious combination of the apparatus. An idea of the mode of proceeding may be formed from the inspection of figure 8. It would be easy to show, that the maximum effect is obtained, when the dimensions of the successive cases rise in a geometrical progression. The action, however, is not doubled for each additional case, but increased rather more than one-half.

Simpler Mode of Congelation;

These plans are difficult in the execution, and though they enlarge our conceptions of the extent of the descending scale of heat, yet they furnish merely speculative results. A very important practical improvement has been lately made in the process of artificial congelation. Sulphuric acid is certainly a cheap and most powerful agent of absorption; but the danger in using such a corrosive liquid, especially by unskilful persons, formed always a serious obstacle to its general adoption. Mr Leslie had early noticed the remarkable absorbent quality of our mouldering whinstone or porphyritic trap; and, in April 1817, he substituted that material, grossly pounded and dried before a kitchen fire, instead of sulphuric acid, and actually froze a body of water with great facility. This earth will attract the fiftieth part of its weight of moisture before its absorbent power is reduced to the one half, and is hence capable of freezing the sixth part of its weight of water. It may be repeatedly dried, and will, after each operation, act with the same energy as at first.

by dry Pounded Whinstone,

or Parched Oatmeal.

But an absorbent still more convenient and powerful has since occurred to Mr Leslie;—it is merely *parched oatmeal*. With a body of oatmeal of a foot in diameter, and rather more than an inch deep, he froze a pound and a quarter of water, contained in a hemispherical porous cup. The meal is easily dried and restored again to its action. In a hot climate, the exposure to the sun alone might prove sufficient. By the help of this simple material, therefore, ice will be easily and safely produced in any climate, and even at sea.

Other substances could, no doubt, be employed as absorbents. But, except the muriate of lime, or what is called the *oil of salt* desiccated, none hold out any prospect of success. Dried common salt will barely effect congelation; and stucco, or the sulphate of lime, deprived of its water of crystallization, which might seem to promise a powerful absorption, has scarcely any efficacy whatever. (D.)

EXPLANATION OF PLATE LXV.

Fig. 1. Represents a large air-pump intended for the purpose of freezing water, consisting of six receivers, each of them having a broad glass saucer for holding sulphuric acid, and a small porous earthen cup containing the water.

Fig. 2. A section of the above, showing the communication between the receivers and the body of the pump.

Fig. 3. The lever key, for opening and shutting the cocks.

Fig. 4. The more ordinary appearance of the surface of the water in the porous cup, at the moment when the act of congelation begins.

Fig. 5. The very singular kind of ice, striated, columnar, and cavernous, which, under a slight rarefaction, but in cold weather, rises slowly and changes its form by degrees, while part of the remaining water is drawn through the substance of the cup, and covers the outside with a thick icy collar above those irregular foliations.

Fig. 6. Represents an elegant mode of almost instantaneously freezing within a transferrer; above the saucer of the sulphuric acid, is placed a glass cup holding water, and the air having been previously exhausted, and the instrument detached from the pump, on pulling up the rod, the water, now left exposed to the most powerful evaporation, quickly runs into spicular ice, which gradually increases and consolidates into a pure transparent mass. The lid being let down again upon the glass cup, the action ceases, and the ice returns slowly to the state of water.

Fig. 7. A refrigeratory for cooling water at all times to a moderate degree, without the operation of an air-pump; a body of sulphuric acid lying at the bottom of the pan, while a porous vessel containing water is set in the centre of the refrigeratory, and the air is confined about it by replacing the lid.

Fig. 8. Exhibits a system of vessels for producing spontaneously great cold. It consists of a series of leaden or pewter vessels, placed one within the other, and whose surfaces form a descending geometrical progression, being covered externally with soft wet lint, and holding each of them a portion of sulphuric acid. The powerful evaporation maintained by this arrangement causes the interior vessels to become successively colder, and thus augments, by a repeated multiplication, the final effect. Placed under the receiver of the air-pump, this system of evaporating vessels, with no very high degree of exhaustion, and at all seasons, excites ultimately the most intense cold yet produced, far exceeding what is required for the congelation of mercury.

☞ *A number of the machines here described have been constructed, under the direction of the inventor, by Mr Cary, Optician, London, and sent to various parts of the Globe. It is only to be regretted, that the demand has not been sufficient for establishing a manufactory of them, which, by greatly reducing the cost, would encourage their general introduction.*

COLD.

PROFESSOR LESLIE'S APPARATUS FOR COOLING AND FREEZING.

Engraved by

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W. & D. Lizars Edinr.

COLONY.

Colony.

Definition.

The term *Colony* has not been used with much precision. Dr Johnson defines it, "A body of people drawn from the mother country to inhabit some distant place;" and it would not be easy to find a short expression better calculated to embrace all the particulars to which, at any time, the term is applied. Yet this will be found to include some very heterogeneous objects; and, what is more, to express particulars to which the term Colony really does not extend. When the French Protestants, for example, settled, in great numbers, in England, and in the United Provinces, they were "a body of people drawn from the mother country to inhabit a distant place," but did not, for that reason, become a colony of France. Let the first part of the definition be supposed to be correct, and that a colony must, of necessity, be "a body of people drawn from the mother country;" something more is necessary to complete the definition, than the idea of inhabiting a distant place; for not every sort of inhabiting constitutes them a colony.

It seems necessary that, inhabiting a distant place, they should not come under the authority of any foreign government, but either remain under the government of the mother country, or exist under a government of their own. Of colonies remaining under the government of the mother country, the West India islands of the different European states afford an example. Of those existing under a government of their own, the most celebrated example is found in the colonies of the ancient states of Greece. The United States of America, as they constituted an example of colonies of the first sort, before the revolution which disjoined them from the mother country, so they may be regarded as constituting an example of colonies of the Grecian sort, now that they exist under a government of their own; though our resentment at their preferring to live under a government of their own, has prevented us from regarding them in the endearing light of a colony, or daughter country—has made us much rather apply to them the name of enemies—and our feelings towards them, to possess a greater share of those of the hostile, than of those of the amicable sort.

Again, however, the term Colony is sometimes employed in a sense in which the idea of a body of people, drawn from the mother country, hardly seems to be included. Thus, we talk of the British colonies in the east, meaning, by that mode of expression, the East Indies. Yet it can hardly be said, that any body of people is drawn from the mother country to inhabit the East Indies. There is nobody drawn to *inhabit*, in the proper sense of the word. A small number of persons, such as are sent to hold possession of a conquered country, go; and, in this sense, all the conquered provinces of the ancient Roman empire might be called, what they never have been called, colonies of Rome.

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In the meaning of the term Colony, the predominant idea among the ancient Greeks and Romans, appears to have been that of the *people*,—the going out of a body of people to a new and permanent abode. Among the moderns, the predominant idea appears to be that of the *territory*,—the possession of an outlying territory; and, in a loose way of speaking, almost any outlying possession, if the idea of permanency is united, would receive the name of a colony. If we use the term with so much latitude as to embrace the predominating idea both of ancients and moderns, we shall say that a colony means an outlying part of the population of the mother country, or an outlying territory belonging to it; either both in conjunction, or any one of the two by itself.

We shall first treat of that class of them in the conception of which the idea of the people is the predominating idea. Of this sort were the Roman and the Grecian colonies, and of this sort are some of the British colonies.

Roman Colonies.

The Roman colonies arose out of a peculiarity in the situation of the Roman people. In that, as in other countries, the lands were originally regarded as belonging to the state; and as belonging to the people, when the people took the powers of government to themselves. A sense of convenience, there, as everywhere else, rendered the land private property by degrees; and, under a form of government so very defective as the Roman, the influence of the leading men enabled them, in a short time, to engross it. The people, when reduced to misery, did not altogether forget, that the land had once been regarded as theirs; and every now and then, asserted their claims in so formidable a manner, that, when aided by circumstances, they compelled the ruling few to make something of a sacrifice. They did not, indeed, compel them to give up the lands which they had themselves appropriated, but it always happened, that in the countries conquered by the Romans, a portion of the lands was public property, and continued to be cultivated for the benefit of the Roman state. When the importunity of the people for a division of lands began to be troublesome or formidable, a portion of these lands was generally resorted to, enough to take off the most fiery of the spirits, and contenting the leaders, to quiet the populace for a time. The portion of land set apart for the purpose was divided, at the rate of so much for every man; and a sufficient number of persons to occupy it, and to form a community, were sent out, more or less provided with the various supplies which were necessary for commencing the settlement.

In the nature of an establishment of this descrip-

tion there is no mystery, and hardly anything which requires explanation. The colonists lived in a Roman province, under Roman laws, and differed not materially from the people of any other local jurisdiction. Being once got rid of, no farther advantage was expected from them than from the other inhabitants of the country, in paying taxes for example, and furnishing men for the army. In some few instances, some benefit in the way of defence was looked to in the planting of colonies, when they were established in newly conquered countries, the people of which were not yet patient under the yoke, or when they were placed in the way of invading enemies. But not much advantage of this sort can be derived from a colony, which in general has more need to receive than ability to yield protection.

These colonies were planted wholly for the benefit of the Roman aristocracy. They were expedients for preserving to them the extraordinary advantages and powers they had been enabled to assume, by allaying that impatience of the people under which the retention of them became difficult and doubtful. The wonder is, that the people were so easily contented, and having certain means of intimidating the aristocracy to so great a degree, they did not insist upon greater advantages. And the pity is, that they understood so little what was for their advantage. If, instead of demanding a portion of land, the benefit of which, at best, was only temporary, they had demanded good laws, and had obtained efficient securities for good government, securities against that prevalence of the interests of the few over the interests of the many which existed to so great an extent in the Roman government, as it has existed and still does exist in almost all other governments, they would have done themselves, and they would have done the human race, the greatest of all possible services. But the progress of the human mind was then too small to enable it to see distinctly what was the real object of good government, or what the means which would be effectual in attaining it.

Grecian Colonies.

We next come to the class of colonies which are exemplified in the case of those sent out by the Greeks; and we take them in order posterior to the Roman, because there is something in them for which rather more of explanation is required. Of those early migrations, which carried a Greek population into Asia Minor, and at a later period into Italy and Sicily, we have not a sufficient number of historical facts, to know very accurately the cause. And it may be, that internal commotions, as often as a superabounding population, were the source from which they were derived. When, of two contending parties, one acquired the ascendancy, they frequently made the situation of their opponents so painful to them, and sometimes also the shame of defeat was so great, that the vanquished party chose rather to live anywhere, than subject to the power and contempt of those over whom they had hoped to domineer. The leaders proposed emigration, and a great part of those who contended under their banners were ready to depart along with them. In this way they might remove in large bodies, and, carrying with them all their moveable effects, would be in circumstances, when they established themselves on a fertile soil, to attain, in a little time, a great degree of prosperity. All this seems necessary to account for so great a degree of prosperity as was attained very early by the Greeks in Asia Minor, where arts and sciences flourished sooner, and civilization made still more rapid strides, till checked by Persian domination, than in the mother country itself, where a more dense population, and a less fertile soil, opposed obstructions to the happiness of the people, and the progress of the human mind.

There is nothing in modern times which so much resembles the colonization of Asia Minor by the Greeks, as the colonization of North America by the English. Of the first English planters of North America, a large proportion went out to escape the oppression of a predominating religion, as the Greeks to escape the oppression of a predominating political party. One difference there was, in that the English did not go off, at once, in any considerable bodies, under distinguished leaders, or with any great accompaniment of capital, the means of future prosperity. Accordingly, the prosperity of the British colonies in North America was much less rapid, and much less brilliant, than that of the Grecian colonies in Asia Minor. Another great difference there was, in that the English colonies, though they made a sort of subordinate government for themselves, were still held to be subject to the government of the mother country. The Grecian colonies became states, in all respects independent, owning no government but that which they established for themselves; though they still looked to the mother country for protection and assistance, and held themselves under a very strong obligation to befriend and assist her in all her difficulties.

In regard to those detachments of the population of the Grecian states which made themselves, either from political disgust, or political oppression, there is nothing which stands in need of explanation. The motive which gave rise to them is familiar and obvious; and the sort of relation in which they and the mother country stood to one another, importing mutual benevolence, but no right in the one to command, or obligation on the other to obey, every body can immediately understand.

There were other occasions, however, on which the Greeks sent out colonies, and these are the colonies which are commonly meant, when the Grecian principle of colonization is spoken of by way of distinction. These colonies were sent out, when the population of the mother country became superabundant, and relief was demanded by a diminution of numbers. This is a ground of colonization, which, since the principle of population has been shown to exert so great an influence upon the condition of human beings, deserves profound regard. We shall not therefore pass it by, without a few observations.

A population is said to be redundant—When? Not when it is numerically of either great or small amount; but solely and exclusively when it is too great for the quantity of food. Any one country produces or procures a certain quantity of food in the year. If it has a population greater than such

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a quantity of food is sufficient to maintain, all that number which is over and above what it is capable of maintaining is a redundancy of population.

Effects of the Principle of Population in Greece.

A curious phenomenon here presents itself. A redundancy of population, in the states of ancient Greece, made itself visible even to vulgar eyes. A redundancy of population in modern Europe never makes itself visible to any but the most enlightened eyes. Ask an ordinary man, ask almost any man, if the population of his country is too great,—if the population of any country in Europe is, or ever was too great?—so far, he will tell you, is it from being too great, that good policy would consist in making it, if possible, still greater; and he might quote, in his own support, the authority of almost all governments, which are commonly at pains to prevent the emigration of their people, and to give encouragement to marriage.

The explanation of the phenomena is easy, but it is also of the highest importance. When the supply of food is too small for the population, the deficiency operates, in modern Europe, in a manner different from that in which it operated in ancient Greece. In modern Europe, the greatest portion of the food is bought by the great body of the people. What the great body of the people have to give for it is nothing but labour. When the quantity of food is not sufficient for all, and some are in danger of not getting any, each man is induced, in order to secure a portion to himself, to give better terms for it than any other man, that is more labour. In other words, that part of the population who have nothing to give for food but labour, take less wages. This is the primary effect, clear, immediate, certain. It is only requisite, farther, to trace the secondary, or derivative effects.

When we say, that, in the case in which the supply of food has become too small for the population, the great body of the people take less wages, that is, less food for their labour, we mean that they take less than is necessary for comfortable subsistence; because they would only have what is necessary for comfortable subsistence in the case in which the supply of food is not too small for the whole.

The effect then of a disproportion between the food and the population, is not to feed to the full measure that portion of the population which it is sufficient to feed, and to leave the redundant portion destitute; it is to take, according to a certain rate, a portion of his due quantity from each individual of that great class who have nothing to give for it but ordinary labour.

What this state of things imports, is most easily seen. That great class, who have nothing to give for food but ordinary labour, is the great body of the people. When every individual in the great body of the people has less than the due quantity of food, less than would fall to his share if the quantity of food were not too small for the population, the state of the great body of the people is the state of sordid, painful, and degrading poverty. They are wretchedly fed, wretchedly clothed, have wretched houses, and neither time nor means to keep either their houses or their persons free from disgusting impurity. Those of them, who, either from bodily infirmities, have less than the ordinary quantity of labour to bestow, or from the state of their families need a greater than the ordinary quantity of food, are condemned to starve; either wholly, if they have not enough to keep them alive, or partially, if they have enough to yield them a lingering, diseased, and after all a shortened existence.

Colony.

What the ignorant and vulgar spectator sees in all this, is not a redundant population, it is only a poor population. He sees nobody without food who has enough to give for it. To his eye, therefore, it is not food which is wanting, but that which is to be given for it. When events succeed in this train, and are viewed with these eyes, there never can appear to be a redundancy of population.

Events succeeded in a different train in the states of ancient Greece, and rendered a redundancy of population somewhat more visible even to vulgar and ignorant eyes.

In ancient Greece the greatest portion of the food was bought by the great body of the people; the state of whom, wretched or comfortable, legislation has never yet been wise enough much to regard. All manual labour, or at least the far greatest portion of it, was performed, not by free labourers serving for wages, but by slaves, who were the property of the great men. The deficiency of food, therefore, was not distributed in the shape of general poverty and wretchedness over the great body of the population, by reduction of wages; a case which affects, with very slight sensations, those who regard themselves as in no degree liable to fall into that miserable situation. It was felt, first of all, by the great men, in the greater cost of maintaining their slaves. And what is felt as disagreeable by the great men is sure never to continue long without an effort, either wise or foolish, for the removal of it. This law of human nature was not less faithfully observed in the states of ancient Greece for their being called republics. Called republics, they were, in reality, aristocracies; and aristocracies of a very bad description. They were aristocracies in which the people were cheated, with an idea of power, merely because they were able, at certain distant intervals, when violently excited, to overpower the aristocracy, in some one particular point; but they were aristocracies in which there was not one efficient security to prevent the interests of the many from being sacrificed to the interests of the few; they were aristocracies, accordingly, in which the interests of the many were habitually sacrificed to the interests of the few; meaning by the many, not the slaves merely, but the great body of the free citizens. This was the case in all the states of Greece, and not least in Athens. This is not seen in reading the French and English histories of Greece. It is not seen in reading Mitford, who has written a *History of Greece* for no other purpose, but that of showing that the interests of the many always *ought* to be sacrificed to the interests of the few; and of abasing the people of Greece, because every now and then, the many in those countries showed, that they were by no means patient under the habitual sacrifice of their interests to the interests of the few. But it is very distinctly seen among other places, in reading the Greek ora-

tors, in reading Demosthenes for example, in reading the *Oration* against Midias, the *Oration on Leptines*, and others, in which the licence of the rich and powerful, and their power of oppressing the body of the people, is shown to have been excessive, and to have been exercised with a shameless atrocity, of which the gentleness and modesty of the manners of modern Europe, even in the most aristocratically despotic countries, do not admit.

In Greece, then, anything which so intimately affected the great men, as a growing cost of maintaining their slaves, would not long remain without serious attempts to find a remedy.

It was not, however, in this way alone, that a redundant population showed itself in Greece. As not many of the few citizens maintained themselves by manual labour, there were but two resources more, the land, and profits of stock. Those who lived on the profits of stock, commonly did so by employing slaves in some of the known arts and manufactures; and of course were affected by the growing cost of maintaining their slaves. Those who lived on the produce of a certain portion of the land could not fail to exhibit very distinctly the redundancy of their numbers, when by the multiplication of families, portions came to be so far subdivided, that what belonged to each was insufficient for his maintenance.

In this manner, then, it is very distinctly seen, why to vulgar eyes there never appears in modern Europe to be any redundancy of population, any demand for relieving the country by carrying away a portion of the people; and why, in ancient Greece, that redundancy made itself be very sensibly perceived; and created, at various times, a perfectly efficient demand for removing to distant places a great proportion of the people.

But what if that redundancy of population which shows itself in modern Europe, in the effects of reduced wages, and a poor and starving people, should suggest to rulers the policy of ancient Greece, and some time or other recommend colonization? A few reflections may be well bestowed upon a supposition of this kind.

General Remarks on the Principle of Population.

In the first place, it should be very distinctly understood what it is we mean, when we say, in regard to such a country as Great Britain, for example, that the supply of food is too small for the population. Because it may be said immediately, that the quantity of food may be increased in Great Britain; a proposition which no man will think of denying.

On this proposition, let us suppose that in any given year, this year for example, the food in Great Britain is too small for the people, by 10,000 individuals. It is no doubt true, that additional food sufficient to supply 10,000 individuals, might be raised next year; but where would be the amelioration, if 10,000 individuals were at the same time added to the numbers to be fed? Now, the tendency of population is such as to make, in almost all cases, the real state of the facts correspond with this supposition. Population not only rises to the level of the present supply of food; but, if you go on every year increasing the quantity of food, population goes on increasing at the same time, and so fast, that the food is commonly still too small for the people. This is the grand proposition of Mr Malthus's book; it is not only quite original, but it is that point of the subject from which all the more important consequences flow,—consequences which, till that point was made known, could not be understood.

When we say that the quantity of food in any country is too small for the quantity of the people, and that, though we may increase the quantity of food, the population will at the same time increase so fast, that the food will still be too small for the people; we may be encountered with another proposition. It may be said, that we may increase food still faster than it is possible to increase population. And there are situations in which we must allow that the proposition is true.

In countries newly inhabited, or in which there is a small number of people, there is commonly a quantity of land yielding a large produce for a given portion of labour. So long as the land continues to yield in this liberal manner, how fast soever population increases, food may increase with equal rapidity, and plenty remain. When population, however, has increased to a certain extent, all the best land is occupied; if it increases any farther, land of a worse quality must be taken in hand; when land of the next best quality is all exhausted, land of a still inferior quality must be employed, till at last you come to that which is exceedingly barren. In this progression, it is very evident that it is always gradually becoming more and more difficult to make food increase with any given degree of rapidity, and that you must come at last to a point where it is altogether impossible.

It may, however, be said, and has been said in substance, though not very clearly, by some of Mr Malthus's opponents, that it is improper to speak of food as too small for the population, so long as food can be made to increase at an equal pace with population; and though it is no doubt true, that, in the states of modern Europe, food does not actually increase so fast as the population endeavours to increase, and hence the poverty and wretchedness of that population; yet it would be very possible to make food increase as fast as the tendency in population, and hence to make the people happy without diminishing their numbers by colonization; and that it is owing wholly to unfavourable, to ill-contrived institutions, that such is not the effect universally experienced.

As this observation has in it a remarkable combination of truth and error, it is worthy of a little pains to make the separation.

There can be no doubt that, by employing next year a greater proportion of the people upon the land than this year, we should raise a greater quantity of food; by employing a still greater proportion the year following, we should produce a still greater quantity of food; and, in this way, it would be possible to go on for some time, increasing food as fast as it would be possible for the population to increase. But observe at what cost this would be. As the land, in this course, yields gradually less and

less, to every new portion of labour bestowed upon it, it would be necessary to employ gradually not only a greater and greater *number*, but a greater and greater *proportion* of the people in raising food. But the greater the proportion of the people which is employed in raising food, the smaller is the proportion which can be employed in producing anything else. You can only, therefore, increase the quantity of food to meet the demand of an increasing population, by diminishing the supply of those other things which minister to human desires.

There can be no doubt, that, by increasing every year the proportion of the population which you employ in raising food, and diminishing every year the proportion employed in every thing else, you may go on increasing food as fast as population increases, till the labour of a man, added upon the land, is just sufficient to add as much to the produce, as will maintain himself and raise a family. Suppose, where the principle of population is free from all restriction, the average number of children reared in a family is five; in that case, so long as the man's labour, added to the labour already employed upon the land, can produce food sufficient for himself and the rearing of five children, food may be made to keep pace with population. But if things were made to go on in such an order, till they arrived at that pass, men would have food, but they would have nothing else. They would have neither clothes, nor houses, nor furniture. There would be nothing for elegance, nothing for ease, nothing for pleasure. There would be no class exempt from the necessity of perpetual labour, by whom knowledge might be cultivated, and discoveries useful to mankind might be made. There would be no physicians, no legislators. The human race would become a mere multitude of animals of a very low description, having just two functions, that of raising, and that of consuming food.

To shorten this analysis, let us, then, assume, what will hardly be disputed, that it is by no means desirable for human nature to be brought into a situation in which it would be necessary for every human being to be employed, and fully employed, in the raising of food; that it never can be desirable that more than a certain portion should be employed in the raising of food; that it must for ever be desirable that a certain proportion should be employed in producing other things which minister to human desires; and that there should be a class possessed of leisure, among whom the desire of knowledge may be fostered, and those individuals reared who are qualified to advance the boundaries of knowledge, and add to the powers and enjoyments of man.

It is no use, then, to tell us that we have the physical power of increasing food as fast as population. As soon as we have arrived at that point at which the due distribution of the population is made between those who raise food, and those who are in other ways employed in contributing to the well-being of the members of the community, any increase of the food, faster than is consistent with that distribution, can only be made at the expence of those other things, by the enjoyment of which the life of man is preferable to that of the brutes. At this point the progress of population ought undoubtedly to be restrained. Population may still increase, because the quantity of food may still be capable of being increased, though not beyond a certain slowness of rate, without requiring, to the production of it, a greater than the due proportion of the population.

Suppose, then, when the due proportion of the population is allotted to the raising of food, and the due proportion to other desirable occupations, that the institutions of society were such as to prevent a greater proportion from being withdrawn from those occupations to the raising of food. This it would, surely, be very desirable that they should effect. What, now, would be the consequence, should population, in that case, go on at its full rate of increase,—in other words, faster than with that distribution of the population, it would be possible for food to be increased? The answer is abundantly plain: All those effects would take place which have already been described as following upon the existence of a redundant population, in modern Europe, and in all countries in which the great body of those who have nothing to give for food but labour, are free labourers:—that is to say, wages would fall; poverty would overspread the population; and all those horrid phenomena would exhibit themselves, which are the never failing attendants on a poor population.

It is of no great importance, though the institutions of society may be such, as to make the proportion of the population, kept back from the providing of food, rather greater than it might be. All that happens is, that the redundancy of population begins a little earlier. The unrestrained progress of population would soon have added the deficient number to the proportion employed in the raising of food; and, at whatever point the redundancy begins, the effects are always the same.

What are the best means of checking the progress of population, when it cannot go on unrestrained, without producing one or other of two most undesirable effects,—either drawing an undue proportion of the population to the mere raising of food, or producing poverty and wretchedness, it is not now the place to inquire. It is, indeed, the most important practical problem to which the wisdom of the politician and moralist can be applied. It has, till this time, been miserably evaded by all those who have meddled with the subject, as well as by all those who were called upon by their situation to find a remedy for the evils to which it relates. And yet, if the superstitions of the nursery were discarded, and the principle of utility kept steadily in view, a solution might not be very difficult to be found; and the means of drying up one of the most copious sources of human evil; a source which, if all other sources of evil were taken away, would alone suffice to retain the great mass of human beings in misery, might be seen to be neither doubtful nor difficult to be applied.

Connection of this Principle with Colonization.

The only question for which we are here required to find an answer, is that of colonization. When the population of a country is full, and its increase cannot go on, at its most rapid pace, without producing one of the two evils of redundancy, a portion of the people, sent off to another country, may create a

void, which, till population fills up, it may go on as rapidly as before, and so on for any number of times.

In certain circumstances, this is a more desirable resource, than any scheme for diminishing the rate of population. So long as the earth is not peopled to that state of fulness which is most conducive to human happiness, it contributes to that important effect. It is highly desirable, on many accounts, that every portion of the earth, the physical circumstances of which are not inconsistent with human well-being, should be inhabited, as fully as the conditions of human happiness admit. It is only, in certain circumstances, however, that a body of people can be advantageously removed from one country, for the purpose of colonizing another. In the first place, it is necessary, that the land which they are about to occupy should be capable of yielding a greater return to their labour than the land which they leave; otherwise, though relief is given to the population they leave behind, their own circumstances are not better than they would have been had they remained.

Another condition is, that the expence of removal from the mother country to the colonized country, should not be too great; and that expence is usually created by distance.

If the expence is too great, the population which remains behind in the mother country, may suffer more by the loss of capital, than it gains by the diminution of numbers.

It has been often enough, and clearly enough, explained, that it is only capital which gives employment to labour; we may, therefore, take it as a postulate. A certain quantity of capital, then, is necessary, to give employment to the population which any removal for the sake of colonization may leave behind. But if, to afford the expence of that removal, so much is taken from the capital of the country, that the remainder is not sufficient for the employment of the remaining population, there is, in that case, a redundancy of population, and all the evils which it brings. For the well-being of the remaining population, a certain quantity of food is required, and a certain quantity of all those other things which minister to human happiness. But to raise this quantity of food, and this quantity of other things, a certain quantity of capital is indispensably necessary. If that quantity of capital is wanting, the food, and other things, cannot be obtained.

Of that class of colonies, in the conception of which the idea of the people is the predominating idea, we have now explained the principle which is exemplified in the case of the Roman, and that which is exemplified in the case of the Grecian colonies. Belonging to the same class, there are British colonies, in which another, and a very remarkable principle is exemplified. The Greeks planted colonies for the sake of getting rid of a redundant population,—the British, for the sake of getting rid of a delinquent population.

Expediency of a Colony for Delinquents examined.

The bright idea of a colony for the sake of getting rid of a delinquent population, if not peculiar to English policy, is, at any rate, a much more remarkable part of the policy of England, than of that of any other country. We have not time here to trace the history of this very singular part of English policy, nor is it of much importance. Every body knows, that this mode of disposing of delinquents was carried to a considerable height, before this country lost her dominion over the North American colonies, to which she annually transported a considerable portion of her convicts. It will suffice for the present occasion, to offer a few observations on the nature of such an establishment as that of New South Wales.

Considered in the light of its utility as a territory, the colony of New South Wales will be included in the investigation of that class of colonies, in the conception of which the idea of territory is the predominating idea. At present it is to be considered in its capacity of a place for receiving the delinquent part of the British population.

In dealing with a delinquent population, the end to be aimed at,—the security of the non-delinquent,—is considered as double; security from the crimes of this or that individual delinquent himself, and security from those of other men who may be tempted to follow his example. The first object is comparatively easy. It is not difficult to prevent an individual from doing any mischief. What is chiefly desirable is, that the individual who is proved to be a delinquent, should be so dealt with, that the mode of dealing with him may be as effectual as possible in deterring others from the commission of similar offences.

In regard to the first object,—securing society from the crimes of the convicted individual,—there is a good mode, and a bad mode. The best of all modes, unquestionably, is, the reformation of the offender. Wherever this can be accomplished, every other mode, it is evident, is a bad mode. Now, in regard to the reformation of the offender, there is but one testimony,—that New South Wales, of all places on the face of the earth, except, perhaps, a British prison, is the place where there is the least chance for the reformation of an offender,—the greatest chance of his being improved and perfected in every species of wickedness.

If it be said, that taking a man to New South Wales, at any rate affords to the British community security against the crimes of that man; we may answer, that putting him to death would do so too. And we farther pronounce, that saving a man from death with the mind of a delinquent, and sending him to New South Wales to all the effects of his vicious propensities, is seldom doing even him any good.

It is, however, not true, that sending a delinquent to New South Wales secures the British community from his future offences. A very great proportion of those who are sent to New South Wales find the means of returning; and those who do so are, in general, and may always be expected to be, the very worst.

We have a high authority for this affirmation. The committee of the House of Commons, who were appointed in the session of 1812 " to inquire into the manner in which sentences of transportation are executed, and the effects which have been produced by that mode of punishment," stated so-

lemnly in their *Report*, that "No difficulty appears to exist among the major part of the men who do not wish to remain in the colony, of finding means to return to this country. All but the aged and infirm easily find employment on board the ships visiting New South Wales, and are allowed to work their passage home. But such facility is not afforded to the women. They have no possible method of leaving the colony but by prostituting themselves on board the ships whose masters may choose to receive them. They who are sent to New South Wales, that their former habits may be relinquished, cannot obtain a return to this country, but by relapsing into that mode of life which, with many, has been the first cause of all their crimes and misfortunes. To those who shrink from these means, or are unable, even thus, to obtain a passage for themselves, transportation for seven years is converted into a banishment for life, and the just and humane provisions of the law, by which different periods of transportation are apportioned to different degrees of crime, are rendered entirely null."

So much then with regard to the reformation of the individual, and security from his crimes, neither of which is attained. But, even on the supposition that both were ever so completely attained, there would still be a question of great importance; viz. whether the same effects could not be attained at a smaller expence. It never ought to be forgotten, that society is injured by every particle of unnecessary expence; that one of the most remarkable of all the points of bad government is, that of rendering the services of government at a greater than the smallest possible expence; and that one of the most remarkable of all the points of good government is, that of rendering every service which it is called upon to render at the smallest possible expence.

In this respect also, the policy of the New South Wales establishment is faulty beyond all endurance. The cost of disposing in this way of a delinquent population is prodigious. We have no room for details, and there is no occasion for proof; the fact is notorious. Whereas, it is now well known, that, in houses of industry and reformation upon the best possible plan, that, for example, of Mr Bentham's *Panopticon*, which has no parallel, there is little or no expence, there is perfect security against the future crimes of the delinquent, and that to a great degree, by the best of all possible modes,—his reformation.

Thus wretched is the mode of dealing with a delinquent according to such an institution as that of New South Wales, as far as regards the securing of the community from the future crimes of the convicted delinquent. It remains, that we consider it in what regards the deterring of all other men from following similar courses to those of the delinquent.

It is very evident, that this last is by far the most important of the two objects. It is now agreed that this is the end, the only good end, of all punishment, properly so called; for mere safe custody, against the chance of future crimes, and satisfaction to the injured party, are not, in the proper sense of the word, punishments; they are for other ends than punishment, in any point of view in which it is ever contemplated.

The great importance of this above the previous case, consists in this, that when you take security against the crimes of the convicted delinquent, you take security against the crimes of only one man, and that a man in your hands, with whom you can deal as you please. When, by means of the mode of dealing with him, you deter all other men from following similar courses, you provide security, not against one man alone, but many men, any number of men, of men undetected, and not in your power, each of whom may be guilty of many crimes before he can be stopt.

On this point it is only necessary, for form's sake, to write down what is the fact; for every human being of common reflection, must anticipate the observation before it is made. If an assembly of ingenious men, in the character of legislators, had sitten down to devise a method of dealing with delinquents, which, while it had some appearance of securing society from the crimes of the detected individual, should be, to the greatest possible degree, devoid, both of the reality and even the appearance of any efficacy, by its example, of deterring other men from the pursuit of similar courses, they could not have devised any thing better calculated for that preposterous end than the colony of New South Wales. Nothing can operate where it does not exist. The men to be operated upon are in England; the example which should operate is in New South Wales. Much more might be said, but it is unnecessary. In the great majority of cases, a voyage to New South Wales, has not even the appearance of a punishment. Men of that description have neither friends nor affections. They leave nobody or thing whom they like, and nobody who likes them. What is it to such men that they are for a while, or for ever, taken away from England, along, very frequently, with the only sort of persons with whom they have any connection, the companions of their debaucheries and of their crimes?

Examination of the supposed Advantages of Colonies.

We now come to the second grand division of colonies, those, in the conception of which, the idea of territory is the predominating idea. Of this sort are most of the colonies of the states of modern Europe; the British possessions, for example, in the East and West Indies.

The question is, in what way, or ways, abstracting from the questions of population, an outlying territory, considered merely as territory, is calculated to be advantageous; or, in other words, what reasons can any country have for desiring to possess the government of such territories.

There are two ways, which will easily present themselves to every mind, as ways in which advantage may accrue to the governing country. First, these outlying dominions may yield a tribute to the mother country; secondly, they may yield an advantageous trade.

No Advantage to be got in the shape of Tribute.

1. We shall consider the first supposition; that of their yielding a tribute to the mother country. This will not require many words, as it is a supposition which few will be found to entertain. In regard to the West Indies, no such idea as that of a tribute

has ever been formed. Even in regard to those taxes, which a vain and unprofitable attempt was made to impose upon the formerly existing colonies in North America, they were never dreamt of as a tribute, and never spoken of but in a sense contrary to the very idea of a tribute, that of reimbursing to the mother country a part, and no more than a part, of that which they cost her in governing and defending them.

With regard to the East Indies, we believe, there exists more or less of prejudice. Under the ignorance in which the country has remained of East India affairs, it floats in the minds of a great many persons, that, some how or other, a tribute, or what is equivalent to a tribute, does come from the East Indies. Never did an opinion exist more completely, not merely without evidence, but contrary to evidence, evidence notorious, and well known to the persons themselves by whom the belief is entertained. India, instead of yielding a tribute to England, has never yielded enough for the expence of its own government. What is the proof? That its government has always been in debt; and has been under the necessity of continually augmenting its debt, till it has arrived at a magnitude which is frightful to contemplate.

So far is India from yielding a tribute to Great Britain, that, in loans and aids, and the expence of fleets and armies, it has cost this country enormous sums. It is no doubt true, that some acts of Parliament have assumed the existence of a tribute from India, or what has been called a surplus revenue, for the use of the nation. But Parliament, we have pretty good experience, cannot make things just by affirming them. *Things* are a little more stubborn than the credulity of Englishmen. That is, in general, obedient enough to the affirmation of those who lead the Parliament, and who have sometimes an interest in leading it wrong. *Facts* take their own course, without regard to the affirmations of Parliament, or the plastic faith of those who follow them.

A general proposition, on this subject, may be safely advanced. We may affirm it, as a deduction from the experienced laws of human society, that there is, if not an absolute, at least, a moral impossibility, that a colony should ever benefit the mother country, by yielding it a permanent tribute.

Let any body but consider what is included in the word government. And, when he has done that, let him then tell himself that the colonies must be governed. If he has the sufficient quantity of knowledge and reflection, no further proof will be necessary.

No proposition in regard to government is more universal, more free from all exception than this, that a government always spends as much as it finds it possible or safe to extract from the people. It would not suit the limits of the present design to run over the different governments of the world for the experimental proof of this proposition. We must invite every reader to do it for himself. Of one thing we are perfectly sure, that the more profoundly he is read in history, the more thoroughly will he be convinced of the universality of the fact.

Now, then, consider whether this universal fact be not inconsistent with the idea of benefit to the mother country by receiving a tribute from the colony. The government of the mother country itself cannot keep its expences within bounds. It takes from the people all it can possibly take, and is still going beyond its resources. But if such is the course of government at home, things must be worse in the colonies. The farther servants are removed from the eye of the master, the worse, generally speaking, their conduct will be. The government of the colonies, managed by delegates from home, is sure to be worse, in all respects, than the government at home; and, as expence is one of the shapes in which the badness of government is most prone to manifest itself, it is sure, above all things, to be in proportion to its resources more expensive. Whatever springs operate at home to restrain the badness of government, cannot fail to operate with diminished force at the distance of a colony. The conclusion is irresistible. If the government of the mother country is sure to spend up to the resources of the country; and a still stronger necessity operates upon the government of the colony to produce this effect, how can it possibly afford any tribute?

If it be objected to this conclusion, that this propensity of governments to spend may be corrected, we answer, that this is not the present question. Take governments as, with hardly any exception, they have always been (this is a pretty wide experience); and the effect is certain. There is one way, to be sure, of preventing the great evil, and preventing it thoroughly. But there is only one. In the constitution of the government, make the interest of the many to have the ascendancy over the interest of the few, and the expence of government will not be large. The services expected from government may, generally speaking, be all rendered in the best possible manner at very little expence. Whenever the interests of the many are made, in the framing of governments, to have the ascendancy over the interests of the few, the services of government will always be rendered at the smallest possible expence. So long as the interests of the few are made in governments to have the ascendancy over the interests of the many, the services of government are all sure to be rendered, at the greatest possible expence. In almost all governments that ever yet existed, the interest of the few has had an ascendancy over the interest of the many. In all, the expence of government has, accordingly, been always as great, as, in existing circumstances, the people could be made, or could be made with safety, to give the means of making it.

One other supposition may be urged in favour of the tribute. The expence, it may be said, of governing the colony by a deputation from the mother country, may be escaped, by allowing the colony to govern itself. In that case, the colony will not choose to pay a tribute. If the tribute rests upon the ground of friendship, it will not be lasting. If the mother country extorts it by force, the colony is, in fact, governed by the mother country; and all the expence of that mode of government is ensured. If it be urged that the colony may continue to pay a

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tribute to the mother country, and that voluntarily, because the mother country may be of use to it; that, we may answer, is a bargain, not a tribute. The mother country, for example, may yield a certain portion of defence. But the colony is saved from the expence of providing for itself that defence which it receives from the mother country, and makes a good bargain if it gets it from the mother country cheaper than it would be provided by itself. In this case, too, the expence incurred by the mother country is apt to be a very full equivalent for the tribute received. It is evident, that this sort of bargain may subsist between any two states whose circumstances it may suit, and is not confined to a mother and daughter country. It is therefore no part of the question relating to colonies.

Inquiry as to the Advantages to be got by Trade.

2. We have now investigated the first of the modes in which a colony, considered as territory merely, may be expected to benefit the mother country; and we have seen the chances of good which it affords. We shall now proceed to investigate the second; the trade, by means of which it is supposed that colonies may benefit the mother country.

This is a topic of some importance; for it is on account of the trade that colonies have remained an object of affection to Englishmen. It is on account of trade solely that the colonies in the West Indies are valued. It is indeed true, that some idea of something like a tribute from the East Indies has till this time maintained a place in the minds of the unthinking part of the community. But still it is the trade which has been supposed to be the principal source of the advantage which has been ascribed to what we call "the British Empire in the East."

Dr Adam Smith produces a long train of reasoning to prove, that it never can be advantageous to a country to maintain colonies merely for the sake of their trade.

View of Dr Smith's Reasonings.

In the idea of deriving a peculiar advantage from the trade of the colonies, is necessarily included the idea of monopoly. If the trade of the colony were to be free, other nations would derive as much advantage from it as the mother country; and the mother country would derive as much advantage from it, if the colony were not a colony.

Dr Smith affirms that this monopoly can never be of any advantage; must always, on the contrary, be a source of great disadvantage to the mother country.

He argues thus:—To make the monopoly advantageous to the mother country, it must enable the mother country to buy cheaper, or sell dearer, in the colony, than it would otherwise have done. In other words, it must enable the mother country to obtain the goods of the colony for a smaller quantity of her own goods than she could without the monopoly. This, in the opinion of Dr Smith, it does not belong to the monopoly to accomplish. The monopoly, he says, may enable the mother country to make other nations pay dearer for the goods of the colony, but it cannot enable her to buy them cheaper. This he seems to take as a postulate, without attempting much to support it by reasoning. The extension of the market, he says, by which he must mean, the competition of capital, would, in a state of freedom, reduce the profits of stock in the colonies to their lowest terms. Under a monopoly he seems to think that profit of stock in the colonies is apt to remain above that level. And he assumes, that the terms on which the mother country deals with the colony must depend upon the rate of profits in the colony.

Having, on these grounds, assumed the impossibility of deriving any advantage from the monopoly of the colonial trade, Dr Smith proceeds to represent a variety of disadvantages which he thinks it has a necessary tendency to produce.

His argument is, that the monopoly of the colonial trade necessarily raises the profits of stock in the mother country; and that "whatever," to use his own expression, "raises in any country the ordinary rate of profit higher than it otherwise would be, necessarily subjects that country both to an absolute and to a relative disadvantage, in every branch of trade of which she has not the monopoly."

To prove the first of these propositions, he says, that by the monopoly of the trade of any colony, foreign capital is driven from it; the capital of the trade is thus made deficient; the profit of the capital is, for that reason, increased; the increase of profit in the colony draws capital from the mother country; the departure of capital from the mother country makes the portion of capital in the mother country deficient; and hence raises in the mother country the profits of stock.

To prove the second of the propositions, he says, that high profits produce high prices; and that high prices diminish produce. To afford her merchants the high profits in question, the country must pay dearer for the goods she imports; and must sell dearer those which she exports. She must therefore, he infers, "both buy less and sell less; must both enjoy less and produce less, than she otherwise would do." Nor is this all; other nations, who do not subject themselves to this disadvantage, to this diminution of produce, may advance faster, and thus attain a superiority which they would not otherwise have enjoyed. And there is still a worse evil; "by raising the price of her produce above what it would otherwise be, it enables the merchants of other countries to undersell her in foreign markets, and thereby to justle her out of almost all those branches of trade of which she has not the monopoly."

To this reasoning, Dr Smith anticipates an objection. It may be affirmed, that the colony trade is more advantageous than any other trade; and though it may be true, according to the reasonings of Smith, that the monopoly of the colony trade has diminished the amount of trade which the mother country,—which England, for example, has been able to carry on in other channels; England has lost nothing, because she has exchanged a less profitable for a more profitable employment of her capital.

In answer to this objection, Dr Smith endeavours to prove, that the employment into which the capital of England is forced by the monopoly, is less advantageous to the country than that into which it would have gone of its own accord. As the foundation of his reasoning, he assumes, that "the most

advantageous employment of any capital to the country to which it belongs, is that which maintains there the greatest quantity of productive labour, and increases the most the annual produce of the land and labour of that country." Upon this principle, he maintains, that the home trade is more advantageous than any trade of export and import, because the same capital puts in motion two portions of industry, that of the buyer and that of the seller. That the trade of export and import, in which the returns of capital take place at short intervals, is more advantageous than a trade in which they take place at distant intervals; as a capital which returns, for example, twice in the year, puts in motion twice as much industry in the mother country, as one which returns only once in the year: And that a carrying trade is the least advantageous of all trades, because it serves to put in motion, not the industry of the country to which it belongs, but the industry of the two countries, the communication between which its employed to maintain. The colony is, therefore, less advantageous than the home trade; it is less advantageous than the trade with the neighbouring countries of Europe; and a great proportion of it is less advantageous than any trade of export and import, because it is a mere carrying trade. The employment into which the capital of Great Britain is forced by the monopoly of the colony trade, is, therefore, a less advantageous employment than that into which it would have gone of its own accord.

We have stated this train of reasoning, which hitherto has passed with political economists as conclusive, the more carefully, because there are several positions in it, which the late profound work of Mr Ricardo (*Principles of Political Economy and Taxation*), who has thrown so much light upon the science of Political Economy, has taught us to control.

Remarks on Dr Smith's Reasonings.

First, as to the position, that the monopoly of the trade of a colony cannot enable the mother country to buy cheaper or sell dearer in the colony; in other words, to obtain a given quantity of the goods of the colony for a less quantity of her own goods, than she would otherwise do, Mr Ricardo would reason as follows: If the trade of the colony is left open to all the merchants of the mother country, it will no doubt happen, that the competition of these merchants, one with another, will make them sell as cheap in the colony as they can afford to sell, that is, buy as dear as they can afford to buy. The produce of the colony will, in that case, go as cheap to the foreign as to the home consumer.

But there is another case; namely, that in which the trade of the colony is placed in the hands of an exclusive company. In that case it is, on the other hand, true, that the mother country may obtain a given quantity of the goods of the colony for a less quantity of her own goods than otherwise she would do. In this case, the goods of the mother country are placed, with regard to the goods of the colony, in the situation in which those commodities which can only be produced in a limited quantity, particular wines, for example, which can only be produced on one particular spot, are placed with regard to all the rest of the goods in the world. It is evident that any quantity of the rest of the goods in the world may be given for those wines, if people are sufficiently desirous to possess them; that there is no limit, in short, to the quantity, but the unwillingness of people to part with more of the things which they possess to obtain the commodities which are thus in request. The same would be the case with a colony, the trade of which was entirely in the hands of an exclusive company. The exclusive company, by limiting the quantity of the goods of the mother country which they chose to send to the colony, might compel the colony to give for that limited quantity any quantity of the produce of their own land and labour, which their desire to obtain the goods of the mother country would admit. If the goods of the mother country were goods which excited a very strong desire, if they were goods of the first necessity, the necessary materials of food or the instruments of their industry, there would be no limit but one to the greatness of the quantity of their own produce which they might be compelled to pay for a given quantity of the produce of the mother country. When nothing was left to the colony of the whole produce of its labour but just enough to keep the labourers alive, it could not go any farther. Up to that point, if dependent for articles of the first necessity, it might, by an exclusive company, undoubtedly be stript.

Even in the other case of the monopoly, that in which the trade with the colony is not placed in the hands of an exclusive company, but open to all the merchants of the mother country, one situation of the mother country may be supposed, in which she might still draw an extraordinary advantage from the forced trade of the colony.

The facts would be these. Whatever foreign goods the colony bought, she would be still obliged to purchase from the mother country. No doubt, the competition of the merchants of the mother country would, in this case, compel them to sell as cheap to the colony as to any other country. Wherein, then, would consist the advantage? In this, that England might thus sell in the colony, with the usual profits of stock, certain kinds of goods, which not being able to manufacture so cheaply as some other countries, she would cease to manufacture, except for the monopoly. But still a very natural question arises,—What advantage does she derive from forcing this manufacture, since she makes by it no more than the ordinary profits of stock, and might make the ordinary profits of stock by the same capital in some other employment? The answer is, that she might by this means obtain a greater quantity of the goods of the colony, by a given quantity of the produce of her own labour, or, what comes to the same thing, an equal quantity of the goods of the colony, by a less quantity of the produce of her own labour, than she could in a case of freedom.

It may be seen to be so in this manner. England desires to purchase, say 10,000 hogsheads of sugar. This is her consumption. For this she will give, of the produce of her own labour, whatever quantity it is necessary to give. She wishes, however, to give as little as possible; and the question is, in what way

she may give the least. The sugar is worth, say L. 500,000. England sends goods to the colony which sell for L.500,000. Now, apply the supposition introduced above. Suppose that, if trade were free, these goods from England, which the manufacturers and merchants of England cannot afford to sell for less than L. 500,000, could be had for L. 400,000 from some other country. In that case, it is evident that the same quantity of these same goods with which England, under the monopoly, purchased 10,000 hogsheads of sugar, would now purchase only 8000; for that is the ratio of the L. 400,000 to the L. 500,000. What then would happen, supposing England still to resolve upon having 10,000 hogsheads of sugar? One of two things must of necessity happen. Either she will purchase the sugar with the same goods, or she will not. If she purchases it with the same goods, it is evident that she must give a greater quantity of goods; she must give one fifth more of the produce of her labour; one fifth more of her industrious people must be withdrawn from administering to other productions, and employed in enabling her to obtain the same quantity of sugar. This quantity of produce, in that case, the mother country saves by means of the monopolized trade of the colony. This quantity she loses by losing such a colony. But, undoubtedly, the mother country would, in such a case, endeavour to purchase the sugar, not with such goods as she purchased it with before, but other goods. She would endeavour to purchase it with goods which she could manufacture as cheaply as any other country. But supposing the colony had no demand for any goods which the mother country could afford as cheap as any other country, even in that case the mother country would still have a resource. If there was any country in which she could sell such goods for money, she could purchase the same quantity of sugar for the same quantity of the produce of her own labour as before.

It is not then true, according to Dr Smith, that in no case can the mother country derive any peculiar advantage in the way of trade, from the possession of colonies. We see that there are two cases, in which she may derive an advantage in that way. It remains to inquire what that advantage is ultimately worth; not only what it is in itself independently, but what it is, after compensation is made for all the disadvantages with which the attainment of it is naturally attended.

We are first to inquire, What is the value of that advantage, all deductions made, which the mother country may derive, through an exclusive company, from the trade of a colony?

No ultimate Advantage derived from the exclusive Trade of Colonies.

It is very evident, in the first place, that, whatever the mother country gains, the colony loses. Now, if the colony were part of the dominions of a foreign state, there is a certain way of viewing such questions, in which that result would appear to be perfectly desirable. But, suppose that the colony, which is the fact, is not part of the dominions of a foreign state, but of the same state; that it is, in truth, not part of a different country, but of the same country; its subjects, not part of a different community, but of the same community; its poverty or riches, not the poverty or riches of another country, but of the same country; How is the result to be viewed in that case? Is it not exactly, the same sort of policy, as if Yorkshire were to be drained and oppressed for the benefit of Middlesex? What difference does it make, that one of the portions of the same empire is somewhat farther off than another? Would it, for that reason, be more rational to pillage Caithness, than to pillage Yorkshire, for the sake of Middlesex? Does the wealth of a state consist in the wealth of one part, effected by the poverty of another part? Does the happiness of a state consist in the happiness of one part, effected by the misery of another? What sort of a rule for guiding the policy of any state would this be supposed? Assuredly this would be a contrivance, not for increasing her wealth and happiness, upon the whole. It would be a contrivance for diminishing it. In the first place, when of two parties equally provided with the means of enjoyment, you take a portion from the one, to give it to the other, the fact is,—a fact too well established, and too consonant with the experience of every man, to need illustration here,—that you do not add to the happiness of the one, so much as you take from the happiness of the other; and that you diminish the sum of their happiness taken together. This, in truth, is the foundation, upon which the laws for the protection of property rest. As the happiness of one man is, or ought to be, of no more value to the state, than the happiness of another man, if the man who takes from another man a piece of property, added to his own happiness, as much as he took from the happiness of the other, there would be no loss of happines upon the whole, and the state would have no ground, in utility, on which to interfere.

But this is not all. Not only is the quantity of happiness of the community diminished upon the whole, but by that operation which gives the mother country an advantage by the trade of the colony, the quantity of produce of the community is diminished upon the whole. The subjects of the state, taken as a whole, not only enjoy less than they would otherwise enjoy, but they produce less than they would otherwise produce. The state is not a richer state; it is, on the contrary, a poorer state, by means of such a colonial policy.

By means of such a policy, a portion of the capital of the state is employed in a channel in which it is less productive than it would have been in the channel into which it would have gone of its own accord. It is a point established in the science of Political Economy, that it is not good policy to confine consumption to any sort of home manufacture, when it can be purchased more cheaply abroad. It is upon this ground that we have laughed at the late and present outcries of the Germans, because the English sell their goods cheaper than they can make them. The reason is, because when a country continues to consume an article made at home, which it could get cheaper from another country, it does neither more nor less than insist, that it shall employ a certain number of men's labour in providing it with that article, more than it would be necessary to employ if it imported the article; and,

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of course, it loses completely the benefit of these men's labour, who would be employed in producing for it something else, if they were not employed in producing that article. The country is, therefore, the poorer, by the whole value of these men's labour. The case is exactly the same, where the colonies are confined to the manufactures of the mother country. When the colony is obliged to employ, for the purpose of obtaining a certain quantity of goods from the mother country, the labour of a greater number of men than she would be obliged to employ to get the same quantity of goods from another country, she loses the labours of all that additional number of men. At the same time, the mother country does not gain it; for, if the mother country did not manufacture for the colony, her capital would be liberated to another employment, and would yield the same profits in that as it did in the former employment.

We have still, however, to examine that extraordinary case which we before supposed, in which the mother country cannot produce any sort of commodity whatsoever as cheap as other countries; and, if trade were free, of course would sell nothing in a foreign market. The case here is somewhat altered. In liberating the colony from the monopoly of the mother country, there would be no change of capital from a less to a more productive employment; because, by the supposition, the mother country has not a more productive employment to which her liberated capital can be sent. Events would succeed in the following order: The colony would obtain the goods which it demanded, with a smaller portion of its own labour,—would hence be more amply supplied with goods. But it is not supposed that this event would give to its industry a more beneficial direction. In the case of a sugar colony, at any rate, its industry would remain in the same channels as before. Such would be the effects in regard to the colony. What would they be in regard to the mother country? If her capital is no longer employed in manufacturing for the colony, she can always, indeed, employ it with the same profit as before. But she still desires the same quantity of sugar; and her goods will not go so far as before in the purchase of it. Whatever fall would be necessary in the price of her goods to bring them upon a level with the goods of other countries, is equivalent, as far as she is concerned, to a rise of the same amount, in the price of sugar. In this case, the mother country would lose exactly as much as the colony would gain. The community, taken as a whole, would be neither the richer nor the poorer, for driving things out of the free into the compulsory channel. The people of the mother country would be so much the richer,—the people of the colony would be so much the poorer.

This, however, still remains to be said. There is only one case in which this sort of monopoly would not diminish the produce of the community, and render it positively poorer upon the whole. There is only that one case, supposed above, in which the mother country has not one commodity which she can sell as cheap as other countries. Now this may fairly be regarded as a case, if not altogether, at any rate very nearly impossible. It is not easy to conceive a country so situated, as not to have advantages in regard to the production of some sorts of commodities, which set her on a level with other countries. As long as this is the case, she can obtain money on as good terms as any other country; and if she can obtain money on as good terms, she can obtain sugar, and every thing else.

The question, then, as to the benefit capable of being derived from a colony through the medium of an exclusive trade, is now brought to a short issue. There is no benefit, except through the medium of a monopoly. There is only one case in which the monopoly does not make the whole community poorer than it would otherwise be. In that case, it does not make the community richer than it would otherwise be; and that case is one, which can either never be realized, or so rarely, as to be one of the rarest of all exceptions to one of the most constant of all general rules. The policy of holding a colony for the benefit of its trade, is, therefore, a bad policy.

Farther Remarks on Dr Smith.

To these conclusions, one or two of the doctrines of Dr Smith will be seen to be opposed, and, therefore, require a few words of elucidation.

If an advantage, in the two cases just explained, would arise from colonies, it would be counterbalanced, he says, by the disadvantage attending the rise in the profits of stock.

Both parts of this doctrine may be disputed. In the first place, it may be disputed, whether the monopoly of the colony trade has any tendency to raise the profits of stock in the mother country. In the next place, it may be disputed, whether a high rate of profits in any country, has any tendency to lay it under any disadvantage in its traffic with other nations.

First, it may be disputed, whether the monopoly of the colony trade would increase profits. The expulsion of foreign capital would create a vacuum, whence, according to Smith, a rise of profit, and an absorption of capital from the mother country. The question is, whether capital would not flow into the colonies from the mother country, till it reduced the profits in the colony, to the level of the profits in the mother country, instead of raising those in the mother country, in any degree toward a level with those of the colony. That it would do so appears to be capable of demonstration. Mr Ricardo's argument would be very short. Nothing, he would say, can raise the profits of stock, but that which lowers the wages of labour. Nothing can lower the wages of labour, but that which lowers the necessaries of the labourer. But nobody will pretend to say that there is any thing in the monopoly of the colony trade, which has any tendency to lower the price of the necessaries of the labourer. It is, therefore, impossible that the monopoly of the colony trade can raise the profits of stock. By those who are acquainted with the profound reasonings of Mr Ricardo, in proof of the two premises, this argument will be seen to be complete. There is not a demonstration in Euclid, in which the links are more indissoluble. To those who are not acquainted with those reasonings, we are aware that the pro-

positions will appear mysterious; and yet, we are afraid that, in the few words to which we are confined, it will not be possible to give them much satisfaction.

With regard to the last of the two propositions, that nothing can lower the wages of labour, but that which lowers the necessaries of the labourer, we may confine ourselves to that combination of circumstances which marks the habitual state, without adverting to the modifications exemplified in those states of circumstances which are to be regarded as exceptions. The habitual state of population is such, that wages are at the lowest terms; and cannot be reduced lower without checking population, that is, reducing the number of labourers. In this case, it is self evident, that nothing can lower the wages of labour, but lowering the necessaries of the labourer. In all, then, except the extraordinary cases, which it would require too many words here to explain, in which a country is but partially peopled, and in which part of the best land is still unemployed, the proposition of Mr Ricardo is indisputable, that nothing can lower the wages of labour except a fall in the necessaries of the labourer.

Let us next consider the proposition, That nothing can raise the profits of stock but that which lowers the wages of labour.

One thing is perfectly clear, that if the whole of what is produced by the joint operations of capital and labour, were, whatever it is, divided, without deduction, between the owner of the stock, and the labourers whom it employs, in that case, whatever raised the wages of labour, would lower profits of stock, and profits of stock could never rise except in proportion as wages of labour fell. The whole being divided between the two parties, in whatever proportion the one received more, it is certain that the other would receive less.

But what is here put in the way of supposition, viz. that the whole of what is produced by the joint operations of capital and labour is divided between the capitalists and the labourers, is literally and rigidly the fact. It is, then, undeniable, that nothing can raise the profits of stock, but that which lowers the wages of labour.

The whole produce, without any exception, of every country, is divided into three portions, rent, wages, and profits. If there were no rent, and the whole were divided into profit and wages, the case would be clear; because nothing could be added to the one without being detracted from the other.

Rent, however, does, in reality, make no difference. Rent is no part of the joint produce of labour and capital. It is the produce, exclusively, of a particular degree of fertility in particular lands; and is yielded over and above a return to the whole of the labour and capital employed upon that land, over and above a return equal to the joint produce of an equal portion of labour and capital in any other employment.

So much, then, for Dr Smith's opinion, that the monopoly of the colonial trade raises the profits of stock. Let us next inquire if it be true, that a rise in the profits of stock, if it were produced by the monopoly, would occasion, as he supposes, any discouragement to the foreign trade of the mother country.

It would occasion this discouragement, he says, by raising prices. If, then, it can be shown, that it would certainly not raise prices, every reason for supposing that it would afford any discouragement to foreign trade is taken away. But that a high rate of profits does not and cannot raise prices, is evident from what has been deduced above. The whole produce of the joint operations of labour and capital being divided between profit and wages, in whatever degree profit rises, wages fall; the cost of production remains the same as before.

Not only does a variation in the state of wages and profit give no obstruction to foreign trade, a variation even in the cost of production gives no obstruction. A nation exports to another country, not because it can make cheaper than another country; for it may continue to export, though it can make nothing cheaper. It exports, because it can by that means get something cheaper from another country than it can make it at home. But how can it, in that case, get it cheaper, than it can make it at home? By exchanging for it something which costs it less labour than making it at home would cost it. No matter how much of that commodity it is necessary to give in exchange. So long as what it does give is produced by less labour, than the commodity which it gets for it could be produced by at home, it is the interest of the country to export. Suppose that the same quantity of corn which is produced in England by the labour of 100 men, England can purchase in Poland with a quantity of cotton goods which she has produced with the labour of 90 men; it is evident that England is benefited by importing the corn and exporting the cotton goods, whatever may be the price of the cotton goods in Poland, or the cost of producing them. Suppose that the cotton goods could be produced in Poland with the labour of 85 men, that is, less than they are supposed to be produced with in England. Even that would not hinder the trade between them. Suppose that the same quantity of corn, which is raised in England with the labour of 100 men, is raised in Poland with the labour of 80; in that case, it is plain, that Poland can get with 80 men's labour, through the medium of her corn, the same quantity of cotton goods which would cost her the labour of 85 men, if she was to make them at home. Both nations, therefore, profit by this transaction; England, to the extent of 10 men's labour, Poland to the extent of 5 men's labour; and the transaction, in a state of freedom, will be sure to take place between them, though England is less favourably situated than Poland with regard to both articles of production.

In what manner this class of transactions are affected by the intervention of the precious metals: in what manner the precious metals distribute themselves, so as to leave the motives to this barter exactly the same as they would be, if no precious metal intervened, it would require too many words here to explain. The reader who recurs for that explanation to Mr Ricardo, the first author of it, will not lose his time or his pains.

One other disadvantage of the colony trade is ad-

duced by Dr Smith. It turns the capital of the country out of a more into a less profitable employment, by turning it from the home to a foreign trade, from a foreign of quick to a foreign of slow returns, and from a foreign to a carrying trade. This doctrine, too, requires some explanation, and more, to be sufficiently clear, than can here be bestowed upon it. The home trade is not necessarily more advantageous than the foreign, nor the foreign of quick than the foreign of slow returns, nor any of them all than the carrying trade. These trades, it may be allowed, increase the gross produce of a country, in the order in which Dr Smith has arranged them. But a country is happy and powerful, not in proportion to its gross, but in proportion to its net revenue, not in proportion to what it consumes for the sake of production, but to what it has over and above the cost of production. This is an important fact, which, in almost all his reasonings, Dr Smith has overlooked. It will hardly, however, be denied, that in various circumstances, any one of these trades, the carrying trade itself, may be more conducive to a net revenue than any of the rest; and in a state of freedom will be sure to be so, as often as the interest of individuals draws into that channel any portion of the national stock.

We have now, therefore, considered all those cases which, in the study of colonial policy, can be regarded in the light of *species* or classes. There are one or two singular cases, which are of sufficient importance to require a separate mention.

Value of Colonies in reference to the Navy examined.

That English law, which establishes the monopoly of the colonies, at least of the transatlantic ones, professes to have in view, not trade so much as defence. The reason of that round-about policy is, in this manner, deduced. The defence of England stands very much upon her navy; her navy depends altogether upon her sailors; the colony trade and its monopoly breeds sailors; therefore, colonies ought to be cultivated, and their trade monopolized.

Upon the strength of this reasoning, in which, for a long time, it would have appeared to be little less than impiety to have discovered a flaw, the navigation laws, as they are called, were embraced, with a passionate fondness, by Englishmen.

Nothing is worthy of more attention, in tracing the causes of political evil, than the facility with which mankind are governed by their fears; and the degree of constancy with which, under the influence of that passion, they are governed wrong. The fear of Englishmen to see an enemy in their country has made them do an infinite number of things, which had a much greater tendency to bring enemies into their country than to keep them away.

In nothing, perhaps, have the fears of communities done them so much mischief, as in the taking of securities against enemies. When sufficiently frightened, bad governments found little difficulty in persuading them, that they never could have securities enough. Hence come large standing armies; enormous military establishments; and all the evils which follow in their train. Such are the effects of taking too much security against enemies!

A small share of reflection might teach mankind, that in nothing is the rigid exercise of a sound temperance more indispensable to the well-being of the community than in this. It is clear to reason (alas, that reason should so rarely be the guide in these matters!) that the provision for defence should always be kept down to the lowest possible, rather than always raised to the highest possible, terms! At the highest possible terms, the provision for defence really does all the mischief to a community which a foreign enemy *could* do; often does a great deal more than it *would*. A moderate provision against evils of frequent and sudden occurrence, a provision strictly proportioned to the occasion, and not allowed to go beyond it, will save more evil than it produces. All beyond this infallibly produces more evil than it prevents. It enfeebles by impoverishing the nation, and degrading by poverty and slavery the minds of those from whom its defence must ultimately proceed; and it makes it, in this manner, a much easier prey to a powerful enemy, than if it had been allowed to gather strength by the accumulation of its wealth, and by that energy in the defence of their country, which the people of a well-governed country alone can evince.

A navy is useful for the defence of Great Britain. But a navy of what extent? One would not, for example, wish the whole people of Great Britain engaged in the navy. The reason, we suppose, would be; because this would not contribute to strength, but weakness. This is an important admission. There is, then, a line to be drawn; a line between that extent of navy which contributes to strength, and that extent which, instead of contributing to strength, is sure to produce weakness. Surely it is a matter of first rate importance to draw that line correctly. What attempt has ever been made to draw it at all? Can any body point out any land-marks which have been set up by the proper authority? Or, has the matter been always managed without measure or rule? And has it not thus always been an easy task to keep the navy in a state of excess; always beyond the line which separates the degree that would contribute to strength from the degree that infallibly contributes to weakness?

As the passion of England has always been to have too great a navy; a navy, which, by its undue expence, contributed to weakness; so it has been its passion to have too many sailors for the supply of that navy. The sailors of a navy are drawn from the sailors of the maritime trade. But a navy of a certain extent requires, for its supply, a maritime trade of only a certain extent. If it goes beyond that extent, all the excess is useless, with regard to the supply of the navy. Now, what reason has ever been assigned to prove, that the maritime traffic of Great Britain would not, without the monopoly of the colonies, afford a sufficient supply of sailors to a sufficient navy? None, whatsoever: none, that will bear to be looked at. But till a reason of that sort, and a reason of indubitable strength, is adduced, the policy of the navigation laws remains totally without a foundation. In that case, it deserves nothing but rejection, as all the world must allow. It is a violent interference with the free and natural course of things;

the course into which the interests of the community would otherwise lead them; without any case being made to appear which requires that violent disturbance.

The discussion of this supposed benefit of colonies, we shall not pursue any farther; for, as a signal proof of the diffusion of liberal ideas, the policy of the navigation laws has become an object of ridicule, with hardly any defenders, in the British Parliament, as the debates of the last session happily evince.

[Ca]se of Min[in]g Colonies [ex]amined.

There is another singular case, created by mines of the precious metals. A colony may be formed and retained for the sake of the gold and silver it may produce. Of this species of colony we have something of a specimen in the Spanish colonies of Mexico and Peru. The question is, whether any advantage can ever be derived from a colony of this description? The answer to this question is not doubtful; but it is not very easy, within the limits to which we are confined, to make the evidence of it perfectly clear to every body. In one case, and in one case alone, an advantage may be derived. That is the case, in which the colony contains the richest mines in the world. The richest mines in the world always, in the case of the precious metals, supply the whole world; because, from those mines, the metals can be afforded cheaper, than the expence of working will allow them to be afforded from any other mines; and the principle of competition soon excludes the produce of all other mines from the market.

Now, the country, which contains the richest mines, may so order matters, as to gain from foreign countries, on all the precious metals which she sells to them, nearly the whole of that difference which exists between what the metal in working costs to her, and what, in working, it costs at the mines, which, next to hers, are the most fertile in the world. She must always sell the metal so cheap, as to exclude the metal of those other mines from the market; that is, a trifle cheaper than they can afford to sell it. But, if her mines are sufficiently fertile, the metal may cost her much less in working than the price at which she may thus dispose of it. All the difference she may put in her exchequer. In three ways this might be done. The government might work the mines wholly itself: It might let them to an exclusive company: It might impose a tax upon the produce at the mine. In any one of these ways it might derive a sort of tribute from the rest of the world, on account of the gold and silver with which it supplied them. This could not be done, if the mines, without being taxed, were allowed to be worked by the people at large; because, in that case, the competition of the different adventurers would make them undersell one another, till they reduced the price as low as the cost of working would allow. Could the tax at the mine be duly regulated, that would be the most profitable mode; because the private adventurers would work the mines far more economically, than either the government or an exclusive company.

It is evident that this is a mode of deriving advantage from the possession of the richest mines of the precious metals, very different from that which was pursued by the Spanish government, and which has been so beautifully exposed by Dr Smith. That government endeavoured to derive advantage from its mines, by preventing other countries from getting any part of their produce, and by accumulating the whole at home. By accumulating at home the whole of the produce of its mines, it believed (such was the state of its mind) that Spain would become exceedingly rich. By preventing other countries from receiving any part of that produce, it believed that it would compel them to continue poor. And, if all countries continued poor, and Spain became exceedingly rich, Spain would be the master of all countries.

In this specimen of political logic, which it would not be difficult to match nearer home, there are two assumptions, and both of them false: In the first place, that a country can accumulate, to any considerable extent, the precious metals; that is, any other way than by locking them up and guarding them in strong-holds: In the next place, that, if it could accumulate them, it would be richer by that means.

The first of these assumptions, that a country can keep in circulation a greater proportion than other countries of the precious metals, "by hedging in the cuckoo," as it is humourously described by Dr Smith, has been finely exposed by that illustrious philosopher, and requires no explanation here.

On the second assumption, that a country, if it could hedge in the precious metals, would become richer by that process, a few reflections appear to be required.

It is now sufficiently understood, that money, in any country, supposing other things to remain the same, is valuable just in proportion to its quantity. Take Mr Hume's supposition; that England were walled round by a wall of brass twenty miles high; and that the quantity of her money were, in one night, by a miracle, either raised to double, or reduced to one half. In the first case, every piece would be reduced to one half of its former value; in the second case, it would be raised to double its former value, and the value of the whole would remain exactly the same. The country would, therefore, be neither the richer nor the poorer; she would neither produce more nor enjoy more on that account.

It is never then by *keeping* the precious metals, that a country can derive any advantage from them; it is by the very opposite, by *parting with* them. If it has been foolish enough to hoard up a quantity of the produce of its capital and labour in the shape of gold and silver, it may, when it pleases, make a better use of it. It may exchange it with other countries for something that is useful. Gold and silver, so long as they are hoarded up, are of no use whatsoever. They contribute neither to enjoyment nor production. You may, however, purchase with them something that is useful. You may exchange them either for some article of luxury, and then they contribute to enjoyment; or you may exchange them for the materials of some manufacture, or the necessaries of the labourer, and then they contribute to production; then the effect of them is to augment the riches, augment the active capital, augment the annual produce of,

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the country. So long as any country hoards up gold and silver, so long as it abstains from parting with them to other countries for other things, so long it deprives itself of a great advantage.

Cause of the desire to possess Colonies.

If colonies are so little calculated to yield any advantage to the countries that hold them, a very important question suggests itself. What is the reason that nations, the nations of modern Europe at least, discover so great an affection for them? Is this affection to be *wholly* ascribed to mistaken views of their utility, or partly to other causes?

It never ought to be forgotten, that, in every country, there is "a Few," and there is "a Many;" that in all countries in which the government is not very good, the interest of "the Few" prevails over the interest of "the Many," and is promoted at their expence. "The Few" is the part that governs; "the Many" the part that is governed. It is according to the interest of "the Few" that colonies should be cultivated. This, if it is true, accounts for the attachment which most of the countries, that is, of the governments of modern Europe, have displayed to colonies. In what way it is true, a short explanation will sufficiently disclose.

Sancho Panza had a scheme for deriving advantage from the government of an island. He would sell the people for slaves, and put the money in his pocket. "The Few," in some countries, find in colonies, a thing which is very dear to them; they find, the one part of them, the precious matter with which to influence; the other, the precious matter with which *to be* influenced;—the one, the precious matter with which to make political dependents; the other, the precious matter with which they are made political dependents;—the one, the precious matter by which they augment their power; the other, the precious matter by which they augment their riches. Both portions of the "ruling Few," therefore, find their account in the possession of colonies. There is not one of the colonies but what augments the number of places. There are governorships and judgeships, and a long train of *et ceteras;* and above all, there is not one of them but what requires an additional number of troops, and an additional portion of navy,—that is of great importance. In every additional portion of army and navy, beside the glory of the thing, there are generalships, and colonelships, and captainships, and lieutenantships, and in the equipping and supplying of additional portions of army and navy, there are always gains, which may be thrown in the way of a friend. All this is enough to account for a very considerable quantity of affection maintained towards colonies.

But beside all this, there is another thing of still greater importance; a thing, indeed, to which, in whatever point of view we regard it, hardly any thing else can be esteemed of equal importance. The colonies are a grand source of wars. Now wars, even in countries completely arbitrary and despotical, have so many things agreeable to the ruling few, that the ruling few hardly ever seem to be happy except when engaged in them. There is nothing to which history bears so invariable a testimony as this. Nothing is more remarkable than the frivolous causes which almost always suffice for going to war, even when there is little or no prospect of gaining, often when there is the greatest prospect of losing by it, and that, even in their own sense of losing. But if the motives for being as much as possible in war are so very strong, even to governments which are already perfectly despotic, they are much stronger in the case of governments, which are not yet perfectly despotic, and of governments of which the power is still, in any considerable degree, limited and restrained.

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There is nothing in the world, where a government is, in any degree, limited and restrained, so useful for getting rid of all limit and restraint, as wars. The power of almost all governments is greater during war than during peace. But in the case of limited governments, it is so, in a very remarkable degree.

In the first place, there is the physical force of the army, and the terror and awe which it impresses upon the minds of men. In the next place, there is the splendour and parade, which captivate and subdue the imagination, and make men contented; one would almost say happy, to be slaves. All this surely is not of small importance. Then there is an additional power with which the government is entrusted during war. And, far above all, when the government is only limited by the will of a certain portion of the people, as under the British government; by the will of those who supply with members the two houses of Parliament, war affords the greatest portion of the precious matter with which that will may be guided and secured. Nothing augments so much the quantity of that portion of the national wealth which is placed at the command of the government, as war. Of course, nothing puts it in the power of government to create so great a number of dependents, so great a number of persons, bound by their hopes and fears, to do and say whatever it wishes them to do and say.

Of the proposition, that colonies are a grand source of wars, and of additional expence in wars; that expence, by which the ruling few always profit at the cost of the subject many; it is not probable that much of proof will be required.

With regard to additional expence, it can hardly appear to be less than self-evident. Whenever a war breaks out, additional troops, and an additional portion of navy, are always required for the protection of the colonies. Even during peace, the colonies afford the pretext for a large portion of the peace establishment, as it is called,—that is, a mass of warlike apparatus and expence, which would be burdensome even in a season of war. How much the cost amounts to, of a small additional portion, not to speak of a large additional portion, of army and navy, Englishmen have had experience to instruct them; and how great the mischief which is done by every particle of unnecessary expence, they are daily becoming more and more capable of seeing and understanding.

That the colonies multiply exceedingly the causes and pretexts of war, is matter of history; and might have been foreseen, before reaping the fruits of a bitter experience. Whatever brings you in contact

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with a greater number of states, increases, in the same proportion, those clashings of interest and pride out of which the pretexts for war are frequently created. It would exhibit a result, which probably would surprise a good many readers, if any body would examine all the wars which have afflicted this country, from the time when she first began to have colonies, and show how very great a proportion of them have grown out of colony disputes. (F. F.)

COMMERCE.

As the *history* of Commerce has been already given in the body of the work, and, as the discussion of its nature and principles must necessarily be resumed in our article on Political Economy, we mean, at present, to confine ourselves to a very brief exposition of the leading doctrine of that Science in regard to Trade, and to some practical discussions, which seem to find a fitter place here than in any other article. Our more general remarks, then, will relate chiefly to the nature and effects of that very erroneous system of Political Economy, commonly called the *Mercantile System;* and those of a more practical kind will be directed to the consideration of the profits of trade—of those transactions called *speculations*—of the effects of trade upon individual views of national policy—of the effects of long credit—and of the consequences that would result to commerce from the abolition of the restrictive statutes regarding interest of money.

View of the Mercantile System.

I. The basis of the *Mercantile System,* which, though long relinquished by Political Economists, still retains an influence both on Merchants and Statesmen, is, that "wealth consists in the precious metals; that what is gained in trade by one nation must be lost by another; and that our great object in receiving returns should be to get money instead of merchandise." It followed from such notions, that of all possessions, a mining country, such as Mexico and Peru, was the most desirable; hence, in a great measure, our war with Spain, in 1740, which led to our unfortunate expedition to Carthagena, involved us in a contest with France, and caused us, in the course of eight years, an immense waste of blood and treasure.

Though we failed in our favourite object, the influence of the mercantile system continued, and was singularly favoured by the annual statement of custom-house returns. These returns exhibit an apparent excess of exports above imports, and give rise to the notion that the balance is sent over in the shape of money. Supposing the exports of England to the Continent of Europe to amount for any given year to L.20,000,000, and the imports to L.14,000,000, the difference (L.6,000,000) is, according to this absurd notion, the amount of profit paid to us in money. It is clear, however, that the custom-house returns take no notice of some very important items, such as the export of public money for our foreign garrisons, the transmission of bills of exchange to foreign merchants, or the import of smuggled goods. Besides, if the *quantum* of our circulating medium remain, as it probably does, very nearly on a par, what becomes of the supposed importation of money? Were England in possession of all the annual balances which the advocates for this system suppose her to have received in money during the last century, our metallic stock would not be below L.400,000,000 Sterling; that is, ten times its actual amount!

When a merchant exports goods, the sale, of course, takes place abroad, and a remittance is made, either by bill or by the return of other merchandise. It hardly ever enters into the contemplation of the exporter that he would find an advantage in obtaining a return in coin or bullion. Money owes the reputation it has acquired, as an object of national interchange, to its convenience in other points; to its being the commodity with which we regularly go to market, and to its fitness for the smallest purchases by the minuteness of its subdivisions. But this recommendation, however important in private business, should have no weight in the intercourse of nations: Merchants can be at no loss to dispose of a remittance made in the shape of goods; nor is it any object with them to multiply the means of petty purchases.

The interest of a commercial country is not to increase the amount of its currency, but to quicken its circulation; the same sum performing double and triple duty when passed expeditiously from hand to hand. Now, nothing promotes circulation so much as exemption from arbitrary interferences, were the effect nothing more than the general preservation of credit. In France, the monstrous abuse made of the paper system in the beginning of the Revolution has long prevented the use of any other circulating medium than coin; the result is an annual loss of *three millions sterling* to the public, such being the difference between the cost of paper and the precious metals, even after making allowance for the retention of a portion of the latter sufficient for the purposes of banking.

Some people, however, imagine that, to increase the amount of the circulating medium, is to increase the capital of a country. These persons should recollect that capital is by no means limited to money, but embraces all that mass of property which is devoted to reproductive consumption. When we wish to lend capital, or to employ it in business, we begin by selling the various articles at our disposal; the amount is then in our hands in the shape of money; but this is very transient; the money disappears as soon as we make payment for the new purchases. The public, not having time to enter into all this reasoning, judge from first impressions, and take for granted that money is capital, because its agency is required to put capital in motion. Governments, however, might have saved themselves much trouble in providing supplies of metallic currency; since the na-

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tural course of business will invariably provide them for itself. The plenty or scarcity of the precious metals depend on considerations altogether different from the imagined balance of trade. Specie was so scarce in England in 1809, that Government was not a little embarrassed to find L.200,000 for the Walcheren expedition; yet in that year our custom-house returns presented an apparent balance of above L.7,000,000 in our favour. *

We must not, however, be understood as advancing that the state of mercantile transactions has at no time had an influence on the course of exchange: the great import of corn in 1810 certainly lowered it materially; but this was owing to an extraordinary circumstance—the non-convertibility of our paper money. Had our circulating medium been such as to admit of exportation, and to possess currency on the Continent, the extra imports would have but slightly affected the rate of exchange.

Losses to England from Mercantile System.

No country has suffered so much from the errors of the mercantile system as England; partly on account of the influence of traders and manufacturers in our legislature; partly from the temporizing policy of our ministers, who have seldom scrupled to buy the consent of any great body of the community to a new tax by the grant of some injurious preference. Hence a variety of pernicious regulations in favour of the landed, the shipping, and the manufacturing interests; hence, also, a number of unfortunate measures in our foreign policy

Our ancestors laid it down as a fundamental rule, that there could be no profit on the one hand, without a corresponding loss on the other. They considered trade as a game of mere transfer, and had no idea how a country could derive wealth by an intercourse, however actively or however skilfully kept up, between its own inhabitants. Charles II. entered on the war of 1672 with high hopes, imagining that, by destroying the commerce of Holland, we should not only increase our own, but in a manner absorb that of the world. Political reasons led us afterwards into close alliance with Holland, and prevented the ebullitions of our jealousy in that direction; but the alarming power of Louis XIV. and the prospect of his acquiring the crown of Spain, led us to a closer connection with Portugal, and particularly to the well-known Methven treaty, concluded in 1703, the object of which was to favour the consumption of port wine, in return for a similar preference to our manufactures. The result has been, that we have not scrupled, for more than a century, to punish our palates and injure our health for the sake of an imaginary political advantage; we say imaginary, because France would evidently have agreed to take our manufactures in return for her produce; and if the increase of her trade had, on one hand, the effect of augmenting, to a certain extent, her national power, it would, on the other, have increased her dependence on us, and have rendered a war with us extremely impolitic and unpopular.

Our attachment to Portugal arose, in a great measure, from her not being a manufacturing country, and likely, in the opinion of the calculators of the day, to be so much the more advantageous to us in the capacity of a customer. This notion has prevailed in our councils to a very recent period; the Administration of 1808 and 1809, not scrupling to give encouragement to the export of merchandise, on a large scale, to the unproductive occupants of Brazil and Spanish America. Now, the fact is, that the means of extending our trade, and consequently our profits, with a foreign country, are to be estimated by a quite opposite rule; they depend on the productive power of that country,—on its means of affording equivalents for our commodities; in other words, on its capability of paying for that which it suits us to sell to it. Now, what country was ever wealthy without industry? The mines of Mexico and Peru, the richest the world ever saw, fall, in point of annual produce, far short of the annual value of the cotton, the tobacco, the flour, and other less tempting products of the United States. In like manner, the cochineal, the cocoa, the barilla, and even the indigo of Spanish America, form a small amount when put in competition with the exchangeable commodities possessed by the industrious nations in our own neighbourhood, such as France, the Netherlands, or the North of Germany.

Mercantile Policy of other Countries.

If from our own favourite policy we turn our attention to that of continental states, we find Holland steering a course of impartiality, and guarded from an imitation of our trespasses, not indeed by superior knowledge, but by the characteristic moderation of her government. The northern kingdoms deserve comparatively little attention, their rulers having in general given their thoughts much more to war than to discussions of internal policy. The same thing was long true of a country where the commercial interest has at no time been very considerable; the personal will of the Sovereign, and the influence of the *Noblesse*, having afforded the grand *raisons determinantes* for public measures. Still the history of France is not without traces of the effects of mercantile prejudices: among other regulations of the kind, there formerly existed several for the purpose of favouring linen manufactures instead of cotton, because flax was a home product, while the purchase of cotton carried money out of the country.

At last, it was found out by some Frenchmen of greater sagacity than the rest, that cotton might be safely admitted to entry, the money required to buy it proceeding necessarily from the employment of French industry in some shape or other. But the extent of popular prejudice was most singularly exemplified at the time when it was proposed to permit the unrestrained use of *toiles peintes*, or printed calicoes: every town that had a chamber of commerce remonstrated against it. A deputation sent from Rouen affirmed, that "the proposed measure would throw its inhabitants into despair, and make a desert of the surrounding country." Lyons, the centre of the silk manufacture, declared that "the news had spread terror into all its workshops." Tours

* Appendix to the *Report of the Bullion Committee*, 1810.

"foresaw a commotion likely to cause a convulsion in the body politic;" Amiens asserted that "the proposed act would become the tomb of the manufacturing industry of France;" and Paris declared that "her merchants came forward that they might bathe the throne with their tears." The Government, however, stood firm, the duty on printed calico was withdrawn, and the Inspector General of Manufactures ventured some time afterwards to challenge the authors of these eloquent effusions to compare their predictions with the result. "Will any of you," he said, "deny that the manufacture of painted calico has been the cause of giving a vast extension to the industry of the country, by employing a number of hands in spinning, weaving, bleaching, and printing? Look only to the branch of dyeing, and say whether this change has not done more for it in a few years than other manufactures would have accomplished in a century." Say, *Traité d'Economie Politique*, Book I. chap. xvii.

In some countries Government goes much farther, and still acts in a commercial or manufacturing capacity, notwithstanding all the admonitions of political economists, or the more home felt lessons of experience. The Austrian Government conducts the gold and silver mines of Hungary, and to so little account, that the profit realized from these splendid establishments does not exceed a few thousands a-year. (See Dr Clarke's *Travels*, Vol. IV.) So lately as last summer (June 1817), the French Government, desirous of laying in a stock of corn for Paris, obtained a loan of money, with which they made purchases in the various markets both in and out of the kingdom. The result was most distressing; the price of corn rose from 80s. to 120s. *per* quarter. The people in the provincial towns became apprehensive of a scarcity, and though in general submissive to a fault, attempted at Rouen, and other places, to impede the course of the market, and to prescribe a limit to the price of corn. The alarm once given extended throughout all Europe, and gave occasion to a sudden rise, as may be seen by a reference to the corn prices at the time in London, Amsterdam, and Hamburgh. Nothing, therefore, is more impolitic than the interference of the public treasury with markets, however good the motive; a truth which has been so thoroughly felt in England as to prevent anything of the kind during the last twenty-five years; Government having confined itself, in seasons of scarcity (as 1795, 1800, 1810), to granting an extra bounty on the import of corn.

Modified State of the Mercantile System.

We are next to advert to the mercantile system in its most limited sense, in the shape which it now bears, after all the modifications of the experience of a century and a half. The predilection for the import of "hard dollars" has disappeared among a portion of the public, particularly since making the discovery that bank paper can be made to answer the purposes of gold and silver. But even these persons are far from admitting the doctrines of political economists in all their extent; they still cling to the notion that we should discourage the import of foreign produce whenever a corresponding commodity can be raised at home; that we should impede or even prohibit all foreign manufactures; and that we should not scruple to encourage certain fabrics of our own by bounties. Such is still the creed of the great majority of our merchants and manufacturers; such was, till within these few years, the creed of our Ministers and Presidents of the Board of Trade. It proceeds on the plausible idea that we cannot provide too much employment, and that our people would be in danger of falling short of work were we to purchase finished articles at the hand of foreigners. But there is not in the natural course of things any such deficiency of labour as to make it necessary or even expedient for us to turn things out of their regular order, for the sake of giving employment to our population. Providence has evidently ordained that industry should be at no loss for objects; the interruptions to its peaceful course arise from our own wayward policy, from our restraints, prohibitions, and, above all, from our sudden changes from war to peace, and from peace to war. These are the true causes of such scenes of embarrassment and bankruptcy as we witnessed in 1793 at the close of profound peace, and as we now unhappily witness at the end of a long continued war.

Equally erroneous is the notion, that it is more for our interest to send abroad manufactures than raw produce or money. If you grant a bounty on an export, you do nothing more or less than bribe a foreigner to make a purchase from you; you withdraw from its natural destination a portion of your capital and labour; for the sake of extending one branch of business, you weaken your means of competition in others. The money so long paid in the shape of bounties on one of our most popular exports, we mean British linen under 1s. 6d. a yard, is a public loss not only to the extent in question, but to twice or three times that extent in indirect injury; it has withheld the industry of our countrymen from other lines which they might have prosecuted without a premium, and in which they would have had no occasion to dread the rivalship of their neighbours.

Mr Hume has justly remarked, that in a question of personal right, the perceptions of a half-educated man may be sufficiently sound, but that the case is very different in regard to matters of general policy, where the real is often different from the apparent result. Now, this state of half knowledge has been the origin of almost all our mercantile miscalculations; we have listened to first impressions, and have not scrupled to give them a practical operation by acts of Parliament, without ever considering that the remote consequences would be injurious to ourselves.

To what fatality is it then owing, that, in this mighty commercial country, the public should still be so far behind hand in the knowledge of the principles of trade? Unfortunately these doctrines, though closely connected with the national prosperity, have never formed an object of attention at the English Universities, and but indirectly and imperfectly in those to the northward of the Tweed. Add to this, that most of the works hitherto published on Political Economy, are written in an abstract, unattractive style, fatiguing the attention of the reader by a long series of reasoning, and seldom relieving him by diversity of subject, or by the introduction of practi-

cal illustrations. The public is still in want of a work which should convey the liberal doctrines of the philosopher in the plain language of business, and support the course of reasoning by an appeal to facts familiar to the mind of the merchant. Our limits do not by any means admit of our supplying this deficiency, or of bringing forward the arguments necessary to erect a structure of conclusive reasoning: they have enabled us only to state some of the more important results, to which we shall now make a few additions.

Farther Exposition of the true Principles of Commerce.

We may safely discharge from our minds all that has been said and all that has been written in regard to the greater relative advantage attendant in trading in this or that particular commodity: we may feel satisfied that profits are much more on an equality than is commonly supposed; that no one would long be a dealer in that which did not afford him advantage, or remain a stranger to that which was throwing an extra gain into the pockets of his neighbour. The same rule is applicable in a national sense, the traffic in one commodity being either directly or indirectly as productive of profit as in another. Even foreign articles of luxury should not be discouraged, since the money required to pay for them must be previously raised by the employment of British industry in some useful manner. This affords a new proof of the fallacy of first impressions, and leads to the grand practical conclusion of allowing people to "buy commodities wherever they can be got cheapest, without seeking to favour home produce above colonial or colonial above foreign."

Merchants should possess unrestricted freedom not only in regard to the articles they deal in, but in respect to the time of keeping them back or bringing them to market;—and this not only from the general title which every one has to the management of his own property, but from a conviction that whatever benefits the individual will be productive of corresponding benefit to the public. This is a point of the last importance, as reconciling the lower orders to a variety of unpopular employments of capital, such as buying up goods to be warehoused, and not brought to market till prices are advanced. Take, for instance, the capitalist who buys 1000 hhds. of sugar on its arrival from the West Indies in August, for the purpose of selling it in the succeeding March or April, such a transaction is of use to all parties; affording, in the first instance, a customer for the planter or planter's correspondent; a depository for the public during the season that the article ought in great part to be stored up; and finally a seller, at a time when, without such deposits and such forthcoming of supply, the price might have become exorbitant, and might have continued so until the arrival of the next year's crop. How applicable are these arguments to the most obnoxious of all traders,—the engrosser of corn!

The more we study the natural progress of commerce, the more we shall be satisfied of the expediency of leaving all its various agents to their uncontrolled management. Business then divides itself, particularly in a large city, into a variety of separate branches, each of which may be carried on to a surprising extent by separate establishments. The commission charged by such persons is small, their dispatch extraordinary; capital does not remain locked up in their hands, and goods find their way to the market whenever prices are encouraging, that is, whenever the consumers are in want of them; they are withheld only when the market is glutted, and when to force sales would be productive of eventual injury to the buyers themselves. The doctrine of the happy medium is nowhere more applicable than in commerce: if you reduce prices for one season under what is necessary to indemnify the producer, you discourage production for the next, and you expose yourself to the hazard of a dearth.

Monopoly is now generally admitted to be highly impolitic; no new grants of the kind have been issued among us for many years, and every renewal of the charter of our principal existing association, has been marked by a diminution of its restrictive character. The public are now aware that a privileged company cannot make its purchases abroad on better terms than individuals, and that the chief operation of the privilege is to enhance the sale prices, or, in other words, to put money into the hands of a few at the expence of the nation. They are farther aware that the concerns of a large corporation cannot be managed with the minute economy and vigilance of the private merchant, and that its grand advantage lies in the intelligence and dexterity acquired by the transaction of business to a large extent by one establishment; an advantage of great importance, but which has nothing to do with the possession of exclusive privileges.

It is now about thirty years since the conclusion of our well known commercial treaty with France; a treaty which many on both sides of the channel were inclined to think particularly advantageous to us, and which certainly afforded a grand object of declamation to Bonaparte. The fact, however, is, that such treaties are good only in as far as they give general confidence to the merchants of both countries; whenever they go farther, and interfere by specific provisions, they are infallibly pernicious, and not the least so to the apparently favoured nation. It is a symptom of some promise in the present day that, though backed by all Europe, our ministers did not, in the treaties of either 1814 or 1815, go the length of imposing any restraints on the trade of France, but left things to their free course, subject only to such restrictions as might be deemed indispensable by either Government for the protection of particular branches of manufacture.

The final conclusions to be drawn from the principles of commerce are of the most comprehensive and beneficient nature. They teach us that every nation finds its account in the prosperity of its neighbours; that it would experience a corresponding suffering from their decline; that to aim at engrossing more trade than *naturally falls to our share*, is sooner or later injurious to ourselves; and that war, even when successful, is attended with the most serious losses. War turns to waste a large portion of our productive means; it leaves us oppressed with a ruinous burden in peace; it impedes the future extension of our exports, for the injury done to our neighbours recoils on ourselves; in

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short, it is so replete with evil to the public and individuals, as to be justifiable only in an extreme case, such as the defence of national independence or the overthrow of a tyrannical usurper.

Principles of Commerce, how far understood on the Continent.

In point of knowledge of the great doctrines of political economy, Germany, or, to speak more properly, the Protestant part of Germany, in particular Saxony, may be said to take the lead of other countries on the Continent. The Dutch, however exemplary in their practical legislation, have little turn for speculative reasoning; the French have not patience to follow through its various links, a chain of philosophical deductions, but their admiration of whatever is humane or liberal, makes them wonderfully delighted with the brilliant conclusions of the science. They have the advantage of possessing in the work of Mr Say, already referred to, the best arranged general treatise that has hitherto appeared on the subject; and they are by no means ill prepared for a very extensive application of political improvements; such as the abolition of privateering, the repeal of all heavy duties on foreign goods, and the substitution of inland taxes for those custom-house imposts which impede the free communication of nations. The rest of Europe is so much in the dark, in regard to the great truths of political science, as to see merely through the medium of local governments: this is the case even in Italy, although that country can boast individuals of some note among the writers on the principles of commerce, and the reflecting turn of the people is favourable to such investigations.

Unfortunately, the condition of most countries, but particularly of Britain, is adverse to the speedy application of these simple and beneficent principles. Particular branches of trade are loaded with taxes which cannot be recalled; capital is invested in manufactures raised by means of bounties, which, however impolitic, ought not to be suddenly withdrawn; while, to throw open our ports to the unrestrained import of foreign merchandise, would lead to a general derangement of industry, unfitted as we at present are to withstand the cheaper labour of the Continent. It was admitted by all parties in Parliament in a late memorable debate (13th March 1817), that "unbounded freedom in trade was our true policy;" but it was urged, that to resort to such a course would overthrow too many private interests, and raise too general a clamour, to be practicable for many years. All that can be done in this embarrassing situation is to acknowledge the true system, to approximate to it gradually but surely, to renounce the errors of our ancestors, and, in point of taxation, to impose duties merely for the purpose of revenue, never with the view of encouraging any particular branch at the expence of another.

II. Having thus briefly stated the general doctrine of *Free Trade*, we shall proceed to the practical topics which we proposed to discuss; beginning with the consideration of the average profit of capital employed in trade.

Profits of Trade.

1. It is common to estimate the emolument of a wholesale business in Britain, in a small established concern, at 10 *per cent.* on the capital; moderate calculators will qualify this by calling it between 8 and 10 *per cent.*; but they who are at great pains to take every thing into the account, and to enumerate a variety of petty deductions which escape the sanguine reckoner, will find that in a large concern 7 *per cent.* is in general the extent of the *clear* earnings; leaving only 2 *per cent.* above that which has been the current rate of interest during the last twenty-five years. Mercantile profits are subject to a variety of unforeseen deductions, originating partly in an accumulation of petty expences, but more, at least in business of long credit, from deficient payments. The latter are technically called bad debts, and almost always exceed the anticipated amount, in consequence both of the sanguine temper of our countrymen, and of the actual capital of the buyers being much inferior to its appearance. Secrecy, both as to property and annual profit, is considered a first rate point among mercantile men; to the latter there can be no objection, but the concealment of the amount of capital, and the almost invariable consequence, its exaggeration, is productive of very pernicious effects. It is founded partly on the general vanity, and more, perhaps, on an expectation of direct advantage from the command of credit. But were the practice of transacting with ready money to become general, a merchant would have no greater motive to be thought in affluence than an individual in any other line. Be this as it may, the fact is, that the clear profits of trade, whether home or foreign, whether mercantile or manufacturing, whether retail or wholesale, are greatly below what the world imagines. Many hold a contrary language with regard to trade in general, but few do so in respect to their own particular business. "Ours," they say, "is of limited emolument, but other lines are very different, inasmuch as they admit of speculation and of higher charges." Whoever takes the trouble to question men in almost any business or profession, may reckon on receiving a succession of such answers,—answers not suggested by a wish to deceive or to conceal the profits of the individual, but originating in the general disposition to take the *omne ignotum pro magnifico*. We dwell on this point from a desire to correct, as far as our influence goes, the prevalence of existing errors, and prepare our countrymen for the adoption of that patient and pains-taking course which was the basis of the prosperity of our ancestors, and which alone can extricate us from our present embarrassment. Some years ago, such language would not have been listened to; our minds were kept in a ferment by the fluctuations of war; property, whether in land, houses, or merchandise, had obtained an unexampled value; the majority of the possessors considered themselves the masters of assured fortunes, and never doubted that the general enhancement was an evidence of augmented national wealth.

Now that we have gained every political object, and that we know to our cost how far we are from enjoying internal prosperity, we are more disposed to give attention to the monitor who recalls the almost antiquated maxims of industry and economy, and who tells us, that, though we surpass our neighbours in activity and combination, we have much to

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We are next to see how far these opinions are supported by official documents. The returns for the property-tax have of late afforded considerable means of ascertaining the circumstances of persons engaged in trade. If it be objected that many persons have not made a fair return, we may rejoin that, on the other hand, a number chose to conceal their disappointments from the world, and to pay the tax on an income they had not realized. The total number of *families* deriving an income from trade, manufacture, and professions, in England, Wales, and Scotland, is about 160,000:

120,000 of these returned their incomes under L. 150 a-year.

40,000 were above L. 150 a-year; and of these

3800 declared their income to exceed L. 1000 a-year.

Now, let any of our readers compare this statement with their previous ideas of the mercantile wealth of Great Britain, and they will bring to mind, if we are not much mistaken, an impression that the number of rich merchants throughout the empire greatly exceeded 3800. The total sum paid as property-tax under the head of the "profits of trade, manufactures, and professions," for 1814, was somewhat under $3\frac{1}{2}$ millions, a sum certainly not to be paralleled in any other country, but falling considerably below the anticipation of Mr Pitt when he first introduced the income-tax so long ago as 1798.

We have naturally a strong disposition to contemplate the past or the distant through a magnifying medium, and to believe whatever the confident assertions of others, or the love of wonder in ourselves, suggests with regard to reported wealth. Hence the allegations so confidently brought forward in regard to the riches of ancient cities; hence the notion generally entertained with respect to the rapidity of fortune-making in our foreign settlements. India has long been proverbial in this respect, and it requires much more than the usual stock of information to discover, that if we make allowance for deaths and disappointments from various causes, the proportion of those who succeed in that country is not *greater than at home;* and that a fortune, when it does happen to be made, is the result of the length of time, of a habit of saving favoured by exemption from the expence of a family, of rare political contingencies, or, finally, of unusual opportunities consequent on the mortality of competitors. In point of trade few countries are more limited than India. In the West Indies, the field of industry is wider, particularly for planters, but the ratio of emolument has certainly not been greater, taking the whole of the last twenty years together, than in Great Britain. In support of these assertions, we appeal not to the young beginner, entering with sanguine hopes on his career, nor even to him who is advanced half-way in the eager pursuit, but to all who have passed *a length of years in these countries*, and who possess a sufficient share of reflection to turn their experience to account, by making a deliberate survey between the mother-country and her settlements. Particular instances may be given of the acquisition of mercantile fortunes even in the last ten or twelve years, partly in India, and partly in Canada; but these have been rare, and the result of peculiar circumstances. Equal judgment and exertion have certainly been possessed by many merchants in the West India, American, and Continental branches; yet, we believe, that the whole list of these houses may be fairly challenged for an example of the *rapid* acquisition of fortune since the peace of Amiens.

Another point in which a similar delusion prevails, relates to the effects of war, particularly that of 1793; a war in which we still believe ourselves, and are believed by foreigners to have engrossed and absorbed the commerce of the world. A reference, however, to official documents will show that the exports and imports of the most boasted years of the war in question, were below the peace year 1802, and even below those of our late years of suffering. The flag of our enemies was indeed expelled from the Ocean, but the greater proportion of trade passed into the hands of neutrals: and, when in 1808, we took it out of their possession, we were taught, by dear bought experience, that war, under any circumstances, is adverse to commerce.

These observations must be understood not as intended to depreciate the value of commerce, or to damp the hopes of eventual success. They show, indeed, that the *ratio* of profit is generally small, but they afford the consolatory assurance that mercantile concerns may be carried to a great extent, and that the amount of gain may, in process of time, be rendered very considerable. This leads us to advert to a matter of great interest to us as we now stand, relatively to the rival countries of the Continent. It is a maxim, that commercial establishments, whether in the mercantile or manufacturing line, should be confined to a few objects, and conducted on a large scale. It is by this only that the task of individuals can be simplified; that employment can be subdivided; that work can be put quickly through hands, or that we can provide on the spot a supply of the various and indispensable requisites of business. A large establishment affords the means of employment to every kind of capacity; in fact, the duty is so facilitated as to become, in many cases, a mere routine; while the more intelligent and attentive workmen act as superintendents, the mass of the unambitious and unthinking are occupied with the detail. It is owing to this process of subdivision, and to the relative magnitude of the London workshops, that many articles can be supplied in our metropolis as cheaply as in the provincial towns, where labour is 40 *per cent.* lower: the same rule accounts for the charge on the transaction of business by merchants, accountants, attornies, notaries, and agents, being less heavy than might be apprehended from the enormous expence of living in London. Similar results take place in regard to manufacture in favour of such towns as Birmingham, Sheffield, Manchester, Leeds; and it is to this, more than to any other cause, that we owe our ability to compete with the cheaper labour of the Continent.

Speculation defined.

2. This analysis of the profit of trade leads us to say a few words on a topic which has hitherto been very

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generally misunderstood, we mean the profits of speculation. That term is confined, by politico-economical writers, to the purchase of an article at a given time, with profit. Among men of business, however, this expression has a much more extended signification, and is applied, generally, to incurring extensive hazards of any kind in the hope of extensive emolument; in short, to whatever is foreign to the proper business of the individual, or beyond the control of common rules. It is to such undertakings that vulgar credulity ascribes extraordinary profits; and even well informed men are apt to give way to the assertions so confidently made, of vast occasional gains in this line of business. Dr Smith himself, after remarking (*Wealth of Nations*, Book I. chap. 10.), that to make a fortune in a regular line commonly requires a long life of industry and frugality, adds, no doubt on the faith of repeated assurances from mercantile friends, that there are many examples of fortunes realized by speculators in the course of a few years. Now, the men who embark in speculation are, in general, very loose accountants; their estimate of profits applies to the *gross*, never to the *nett* return; besides, they are almost always adventurers, and adventurers have seldom been noted for the observance of truth. Their favourite season of activity is a time like that of 1808, when the sudden stoppage of ordinary intercourse caused a rapid fluctuation in the prices of commodities, and when the regular merchants withdraw from the scene. Now, what sober estimate can be formed of loss or gain in such a chaos? Add to this that these men trade almost always on credit, and in need of all the support which flattering representations, and rumours of sudden profit, can give them. All these reasons seem to justify a deliberate inquirer in doing what is very seldom done in such occasions, we mean in withholding his belief from the confident allegations of speculators, so long as they are not supported by collateral evidence.

Our opinion is, that, instead of the large profits commonly ascribed to this course of trade, it will be found that the individuals concerned in it experience little else than disappointments, and maintain a perpetual struggle to keep up a fair appearance to the world. This opinion is founded partly on a knowledge of the actual career and circumstances of speculators, but more on the well known fact, that almost every line of business is in the hands of established merchants, who, of course, are too vigilant to overlook the opportunity of emolument, and who have much better means of information than temporary interlopers. Still, should there remain doubts as to the accuracy of our opinion, the question may be brought to a point by a reference to the account-books of any given number of celebrated speculators: their affairs end almost always in bankruptcy; their papers continue open to access for years in the hands of their solicitors or assignees; and we are much mistaken if an inspection of them would show, in one case out of ten, that the parties had at any period succeeded in making their boasted profits.

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Its pernicious Effects.

We have been induced to dwell the more on the boasts of speculators, because they are productive of the greatest mischief in unsettling persons in business, particularly young men, and in making them look on their proper line with comparative contempt. It would be endless to attempt an enumeration of the various ways in which the rage for speculation has brought misfortune on our merchants and manufacturers. The opening of a new country, such as Buenos Ayres, Brazil, or Caraccas, has led to the export not only of a prodigious overstock of merchandise fitted for the country, but of many articles totally unsuited to the climate and habits of the people. *

Again, when the late war was drawing to a close, goods, both colonial and manufactured, were poured into the Continent of Europe, as if the market were inexhaustible, and as if the calamities of war had produced no decrease of disposable capital. At home, also, vast sums have been lavished in buildings, in mines, manufactories, and other establishments which never had a fair prospect of success, and owed their origin to the sanguine imagination of one projector, and the credulity of another.

The result of all this is, that hitherto our trading concerns have been very frequently mismanaged; that a great deal of property has been wasted by the inexperienced and sanguine; and that those who really expect to succeed in business must lay their account with submitting not only to a deal of labour, but of self-denial, in resisting the temptation of flattering projects, out of their own line. What a beneficial result would be produced were young merchants to adopt it as a rule not to listen to the ardent suggestions of persons of their own time of life, but to recur, on every question of consequence, to the advice of their seniors; of men who have had to make their own way in the world, and who, without perhaps possessing the advantage of education, or the talent of moulding their reasoning into the form of general principles, will still be found safe counsellors in the practical part of the business. If the result of their admonitions be to abridge some of the pleasing illusions of the mercantile beginner, is it not better that the true nature of his prospects should be made known to him in the early part of life? A deduction from anticipated enjoyment is a trifling sacrifice in comparison with the distress produced by failure in latter years, when the individual is less able to contend with difficulty, and has probably to provide for a family. Let any one extensively acquainted with mercantile men, call to recollection the situation of the majority of his

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* Elegant services of cut glass were sent out to men accustomed to drink out of a horn or a cocoa-nut shell; skates were forwarded to a country where ice was unknown; and tools with a hatchet on one side, and a hammer on the other, to break the rocks, and cut the precious metals from them, as if the inhabitant had merely to go to the mountains, and cut down gold and silver by wholesale.—*Mawe's Travels to Brazil.*

personal friends during the last twenty years, and say, whether any degree of self-denial would not be preferable to that succession of disappointments, anxieties, and losses, which have baffled the exertions and broken the spirits of so many meritorious persons.

The country in which trade has shone forth in all its splendour, where it has been cultivated without the support of arms or prohibitory regulations, where, in short, it has developed its beneficent tendency in all its extent, is Holland. If we look to the early enterprises of the Dutch, we find them enabled by the power of their productive industry to assert their independence at home, and to assail their enemies in the remotest part of their empire. The Portuguese in the east, and the Spaniards in the west, were each found unequal to the task of resisting these Republicans: a proud stand was made by them against the navy of England, and they did not fall into despair even when assailed by our forces in conjunction with those of France. Afterwards, when happily restored to our alliance, and when they concurred and cooperated with us in the great struggle against Louis XIV., it is surprising how large a proportion both of troops and subsidies was furnished by this apparently inconsiderable state. "No country," says Sir William Temple, "can be found where so vast a trade has been managed, yet the inhabitants have no native commodities towards building vessels, and hardly any that are considerable for traffic with their neighbours. Holland is grown rich by force of industry, by improvement and manufacture of foreign growths." Proceeding to specify more particularly the causes of this mercantile prosperity, Sir William enumerates "the easy communication of water, particularly by the Rhine and Maese; the security of property; the undisturbed liberty of conscience, and the progressive influx of people persecuted for their religious opinions in Flanders, England, France, and Germany." Such were the original causes; those of subsequent operation were the "general habit of industry and economy; the formation of canals; the institution of Banks; the low interest of money; the exemption of trade from imposts; the appropriation of particular towns to particular branches of business; application to the fisheries, and (what he regrets much should not exist in England) the practice of keeping an official register of all purchases of property;" a practice introduced into Holland and Flanders in the reign of Charles V. to the incalculable convenience and security of money transactions.

Effects of Trade upon Individual Views of National Policy.

3. We are now to say a few words on a different topic,—the effects of trade in forming the character of individuals, a matter of no little importance in a country like ours, where merchants both constitute so large a portion of the community, and exercise such influence on the proceedings of Government. The mercantile character has a number of good points, being exempt from the vacuity and indecision so frequent in fashionable life, as well as from the various vices consequent on the habit of idleness, and which are so strikingly exemplified in the gaming and libertinism of the French metropolis. Whatever good is produced by continued activity and by a pointed attention to the specific objects of one's occupation, may be confidently looked for among commercial men; with the farther advantage, in large concerns, of an exemption from petty jealousies and invidious interferences. In such cities as London and Amsterdam, merchants become aware, less by a process of reasoning than by the continued result of experience, that the field is ample for all; that the prosperity of one is very far from impeding that of others; and that when disappointment and failure occur, their origin is to be sought in a very different cause from competition. Here, however, we must close our encomium; and, in the spirit of impartiality, proceed to exhibit the opposite side of the picture. The merchant's knowledge is particular, not general; he obtains a habit of understanding individual character, and a dexterity in managing his own affairs; but he has not, and cannot, from his course of occupation, acquire the power of reasoning comprehensively on the interests of trade. He is, accordingly, a very unfit adviser, or even referee, for a minister or legislator; being accustomed to draw his deductions from his own particular branch of business, or apt, if he go out of it, to form a hasty judgment from first impressions. If he observe in war a tendency to raise prices, or to invigorate particular lines of trade (such as ship-owning or insurance), he will probably be led to the general inference, that, to a maritime country, war is advantageous. Our last contests having been attended with the undisputed command of the ocean, nothing more was required to satisfy the majority of merchants that our mercantile marine was in a state of equal ascendancy: they took *à la lettre* the custom-house reports of our annual exports, without observing how much was to be deducted for the progressive depreciation of money, or how surely we were laying the foundation of foreign rivalship, by submitting to enormous taxation, and a consequent enhancement of provisions and labour. Again, when in 1807 the long continuance of war had given a serious wound to our trade and navigation, a majority of the merchants ascribed it not to the true cause, but to the undermining competition of the Americans. Their range of reflection was not such as to enable them to perceive that, by overturning the prosperity of the latter, we should sap the foundation of our own; and that every million which we prevented our Transatlantic neighbours from adding to their capital, was so much withdrawn from a fund devoted to the increase of the productive industry of Britain. Hence our unfortunate *Orders in Council*, the main cause of the overthrow of our exchanges with the Continent, of the increase of our expences in Spain and Germany, of our war with the United States, in short, of the long continuance of our sufferings since the peace. Can it be necessary to add more to demonstrate the impolicy of being guided in general questions by mercantile men? Let them confine themselves to the sphere of practical exertion; a sphere sufficiently wide to gratify the most ardent or patriotic, assured, as they well may be, that it is not only the road to individual wealth, but the means of furnishing a most effectual addition to the stock of national power.

Commerce.

Bad Effects of long Credit.

4. Nothing would, in our opinion, conduce more to the prosperity of trade than the adoption of the plan of doing all wholesale business for *ready money*, and the relinquishment of that habit of long credit which prompts to unguarded enterprise, and has for so many years been the principal cause of crowding the columns of our Gazettes. Hopes of a change in this respect may now be confidently entertained, partly from the greater plenty of money consequent on a state of peace, and more from the general conviction of the impolicy of limiting the rate of interest by law. The repeal of the restrictive statutes will probably be founded on a partial view of the case, and more particularly on the desire of enabling landholders to obtain loans, without resorting to the disreputable alternative of annuities. Its effects in trade have been little anticipated, but we venture to predict that the extent of beneficial change will far outrun the expectation of the supporters of the measure.

In order to show the results of long credit, it is necessary to go a considerable length into practical illustration, and to apprize those of our readers who are not in the mercantile line, of the real situation of the majority of our manufacturers and export merchants. A manufacturer on the present footing receives orders in the course of a year from twenty or thirty mercantile houses; the goods to be exported probably to the West Indies, the United States, the Spanish Main or Brazil; the understood term of credit fourteen months. The manufacturer does not receive the orders from abroad; he has an intermediate guarantee—that of the exporting merchant. Still the risk is considerable, but he naturally hopes for the best, and is unwilling to decline an order when it comes to him from a quarter of respectability. Now, by mercantile respectability, we must apprize our readers that they are to understand integrity, and the intention of acting up to engagements; the *power* of doing so, especially at a remote date, is a very different question, and is, in general, possessed in a much smaller degree than the public imagines. The trader, whose capital is L. 30,000, will not scruple to ship goods to the value of L. 40,000; first, in the hope so general among merchants, of realizing a handsome profit; and next, in the confidence that, should the foreign market be dull, and should delays occur in obtaining returns within the given time, his credit will procure him indulgence for several months, at the end of which the expected remittances can hardly fail to arrive. He may, and in general does, go on for several years without much embarrassment, receiving, indeed, less than he sends out, but assured that all has been well sold, and cannot fail to be soon realized. He thus goes on, pleasing himself at every balance of his books with the seeming profit, and only regretting that hitherto that profit has not been tangible, since it exists only in the shape of a debt, due by his Trans-Atlantic correspondents. He continues, however, under a favourable expectation of their making up for past deficiencies; and flatters himself that the delay that has hitherto occurred has resulted from partial or temporary causes. He begins to find himself somewhat straitened for funds, but has as yet little difficulty in obtaining relief from a monied friend, or a prolonged credit from the manufacturers. His correspondents continue to write in a strain of confidence, and to call for more goods, which, if he be of a confiding character, will lead him to extend the annual amount of his shipments; but, at all events, he is *obliged* to continue a certain supply for the sake of keeping up the assortment of stock. Still he finds that, year after year, a larger portion of his capital remains on the other side of the Atlantic, and that his correspondents, however desirous (for we by no means put an extreme case), are unable to prevent the accumulation of debt, because they are, in like manner, left unpaid by the inhabitants of the country. To go to law would be of no avail, since it is the policy of almost every government in a recently settled country to favour the debtor, and to give him the means of retaining capital in his hands. Affairs now come to be serious with the exporter; the manufacturers and other creditors cannot or will not give farther time, and demand an explanation of his circumstances. This explanation takes place, and serves to show that their debtor is a man of honour, with more assets than debts; but the latter are certain, while the former are at the distance of 3000 miles. The consequence is a grant of time; an allowance to the debtor of two, three, or four years, to act under letter of licence, in the hope of making up that which cannot, it is evident, be performed sooner. This is, in general, both the most wise and most liberal course; still it is not often found to succeed, because the foreign debts cannot be realized in climates where life is held by so uncertain a tenure, where respectable agents are so rarely found, where buyers of goods have so little capital, and, above all, where the law allows so little support to the creditor. A few of the promised instalments are probably made good; but, in general, the merchant recognises the impracticability of fulfilling the remainder, and finds it eventually necessary to submit to the mortification of a bankruptcy.

Such has been the case of a very large proportion of the mercantile establishments in our outports, and even in London, during the last twenty years. Distressing, indeed, has been the catalogue as exhibited in the Gazette, particularly since 1810; but even at present the public are not aware of the real extent of the failures, because in many the arrangements are private. Add to this, that the attention of the public is seldom so long directed to one object as to lead to conclusions of the general nature now mentioned. The fact, however, is, that old establishments, we mean houses which go back for half a century or more, are almost the only ones which have escaped insolvency. Among houses of recent origin, what a succession of failures has taken place in Liverpool, Glasgow, Manchester, Birmingham, and even in London! But we forbear to enlarge on this distressing picture, and turn for relief to countries which have been exposed to considerable shocks, but which have never conducted business on the system of long credit.

Holland a Country of short Credit.

If we begin with Holland, we find that bargains in that country were, in its better days, almost always made for ready money, or for so short a date as six weeks or a couple of months; profits were small in their ratio, but the quickness of returns

made them eventually large; failures were rare, even in so distressing an era as the occupation of their country by the French, which began in 1795, and involved, from the outset, a stoppage of maritime intercourse with all their possessions in India and America. The consequence of this stoppage was a decay of trade, a suspension of various undertakings, a scarcity of work, a miserable dullness in the sale of goods; all leading, in the first instance, to diminished income, and eventually to encroachment on capital; but, amidst all this distress, the failures were surprisingly few,—fewer, indeed, than occur in Britain in any ordinary season. Another example, equally replete with instruction, is the present state of France, where, ever since the invasion of 1814, there has been very little credit given; and where business has been done for ready money from necessity, exactly as it was formerly done in Holland from choice. Of late years, one great misfortune has followed another in that country. The return of Bonaparte from Elba, the second invasion of the allies, the heavy contributions, the expence of the Army of Occupation, and, worst of all, the bad harvest of 1816, seemed to shake property to its foundation. There prevailed, in fact, a general discouragement among the upper ranks, and a great deal of wretchedness among the lower, trade being at a stand, and stocks of goods lying unsold in shops or warehouses for years; still bankruptcy was and is exceedingly rare. All this shows what a satisfactory prospect we may anticipate when we come the length of transacting the greater part of our business for ready money.

Beneficial Effects that would result from the Abolition of the Usury Laws.

5. Yet we are far from recommending any law or measure to enforce that object; the evident advantage of the plan will not fail to secure its adoption, whenever we succeed in obtaining the removal of the grand legal impediment. What, it may be asked, do we mean by this impediment? We answer, that law which imposes a forced limitation on the rate of interest. By that law, a capitalist is not permitted to take more than 5 *per cent.* interest for the loan of money, whatever may be the risk. If he exceed that limit, he renders himself liable to the ruinous penalties of the laws, or to all the hazards attendant on a mercantile partnership, hazards which affect not merely the sum advanced, but the whole of his fortune. He is consequently obliged to seek other means of employing his money; vesting it in the public funds; confining it to the discount of the best mercantile bills; lending it on mortgage, and not unfrequently sending it out of the country, tempted by the higher interest given in France and other parts of the Continent. Now there are, in all mercantile cities, and particularly in London, a body of capitalists, who are too well aware of the hazards of trade to expose their *whole* property to them, but who would gladly bring forward a fourth, a third, or even a half of it, in the hope of realizing an increased income, and for the sake of enjoying that gratification which attends active employment, and the indulgence of hope and prospect. Men of business are not capable of absolute retirement; the object of their latter years is to lessen anxiety, not to withdraw entirely from the scene of activity. Their habits, their calculations, their attachments, all keep them in connection with their early friends, and with the scene of their exertions: the point, therefore, should be not to urge them, as the law has hitherto done, to an abrupt dereliction of mercantile chances, but to enable them to continue them in a greater or lesser degree, as may suit their circumstances or individual character.

Such would be the effect of a change in regard to the lender. Let us next advert to the situation of the borrower. There is a general disposition in merchants to carry their business beyond the extent of their personal capital, a disposition which has no doubt frequently been carried to excess, but which ought by no means to be subjected to unqualified censure. No one can pretend to draw a general line of distinction between laudable enterprise and sanguine speculation; it must be left to the decision of the individual, and of the connections who support him. Often will it happen that a man of talent and judgment finds his personal funds inadequate to enter on the field of fair and legitimate enterprise, or to procure him an adequate share in an established business. We are perfectly aware that in London, men of this description frequently succeed, in the middle or latter part of life, in becoming partners in well established concerns; but it is equally true, that many of them are doomed to a different lot, and pass their life in uninstructive routine. Counting-house occupation is carried on in comparative retirement; it presents no opportunities of public appearance as in the profession of the Law, and years pass away without bringing an individual into notice with others than his employers and immediate connections. Hence the importance of removing a great impediment imposed by our usury laws, the effect of which is to prevent the capitalist from coming forward to the aid of a promising beginner.

Let us next say a few words on the situation of our manufacturers. A disposition to enterprise existing strongly among our export merchants; the result is, that business must be done; and, if not for money, for credit;—on whom shall the responsibility fall? "Not," says the law, "on the capitalist; if he take more than five *per cent.*, he shall subject himself to the penalties of usury, or he shall risk his whole fortune by a partnership." The spirit of adventure is not, however, to be restrained; orders arrive, and goods must be supplied; the burden of credit is then made to devolve upon the furnishers of these goods, whether manufacturers or wholesale venders. It would be in vain for these persons, particularly the former, to urge that it is entirely out of their line to judge of the stability of the merchant, residing, as he generally does, in a different quarter, and connected with people to whom they are strangers. The case is peremptory, "if *you* do not give credit, we must apply to others who will." The alternative of the manufacturer, or wholesale vender, is then to make such additional charge on his goods, as may prove an indemnity for his average loss; a charge amounting in general to 12, 15, or 18, *per cent.*, and which, besides its magnitude, has the unfortunate effect of pressing equally on the solvent and insolvent buyers. How different will be the case when the ca-

pitalist shall find himself at liberty to stipulate a rate of interest proportioned to his risk! He will look around the circle of his mercantile friends for a man of honour and prudence, offer to supply his deficiency of pecuniary means, receives such security as the case admits of, and bargains, not for a share in the adventure, but for an extra interest, and the repayment of his money at a remote date. The important point once adjusted, what does the merchant do?—He goes to the manufacturer, not as at present, to ask credit for twelve or fourteen months, but with ready money in his hands. What a surprising difference does this make to the manufacturer! instead of adding, and being in fact obliged in self-defence to add the large sum mentioned above, he sells and sells cheerfully at so trifling a profit as $2\frac{1}{2}$, 2, or $1\frac{1}{2}$ *per cent.* for ready money. Nothing can be more erroneous than to suspect a real man of business of aiming at a high profit; security, quick returns, and exemption from perplexed accounts, are his objects; and, when paid in cash, he is saved so much trouble and uncertainty, that his demand becomes extremely moderate. The manufacturer looks for no other indemnity than, first, a reimbursement of his outlay for the raw material; next, a small consideration for the expence of his establishment in rent and salaries, and, finally, a still smaller for his personal trouble. An enlarged income is, no doubt, his eventual hope, but that, he is conscious, must arise not from swelling his charge, but from *extending the scale of his business.* Observe the admirable effects of the ready-money plan on the progressive ramification of business,—it affords the manufacturer the power of purchasing the raw material for ready-money; he obtains it at a reduced price, exactly as the merchant obtains the finished article from him; accounts are greatly simplified; a briskness is given to mercantile transactions in all their stages; an important reduction takes place in the price of export goods, and we become much more able to stand the competition of foreign manufacturers. It is, moreover, no insignificant advantage that our traders are thus enabled to know their real situation, and to be aware of the *limits of their income*, while assured of the security of the principal: they thus become better calculators, and avoid those expences which steal so naturally on the mind of a person accustomed to view the profits through a magnifying medium, and which are one of the great causes of bankruptcy being so much more frequent among merchants than in the other classes of society.

Among other advantages resulting from the adoption of such a plan, would be that of saving a heavy expence, incurred at present by many houses in the collection of debts. A travelling clerk can hardly cost less than L. 400 or L. 500 a-year; and, in the metropolis, where such collections are made by a partner or principal clerk, a deal of precious time is lost in repeated calls on the one hand, and on the other in expedients to postpone the day of settlement. We should no longer see new establishments seeking to procure orders by outbidding their neighbours in offers of prolonging credit; and we might hope to witness the gradual abandonment of certain very costly, and by no means effectual methods of courting business. We allude to the habit of expensive living as a proof of property, and as a means of attracting connections. All such expedients are flattering in the eyes of the inexperienced beginner, but their inefficacy is well known to the veteran merchant, who will not hesitate to declare that were his career to be renewed, he would make a point of avoiding them as well as almost all the steps so frequently embraced for the sake of *pushing business.* In the mercantile, as in other lines, the means of success are few and simple; not easy of attainment, indeed, and requiring, above all, long continued perseverance, but less varied and complicated than a youthful mind is apt to imagine. Analyze the true qualities of a man of business, you will find them reduce themselves to fairness, vigilance, and steadiness,—fairness, exemplified in declaring his terms at once, and in never deviating from an engagement—vigilance in superintending his assistants, his clerks, and his workmen—and steadiness in following up his proper line, year after year, without turning to the right or left in pursuit of speculative advantages. These, plain as they are, form the true virtues of mercantile life; the man who is known to possess them will be at no loss for connections, and may safely leave to others the task of seeking a reputation for hospitality by their mode of living, of activity by the frequency of their solicitations, or of liberality by an unusual prolongation of credit.

In reasoning with such confidence on the good effects of so simple a measure as that of laying open the rate of interest, we may be charged with going too far, and with indulging in sanguine anticipations; but no one can pretend to foresee or to limit the extent of good arising from restoring business to its free course. Again, if we are thought to lay too much stress on the degree of aid to be derived by a supply of capital to the mercantile body, our answer is, that merchants are, in general, much shorter of capital than the public imagine, and that the rate of interest is low only for stock, lands, or other undoubted securities. Such was, in a great degree, the case in 1809 and 1810, yet merchants, it is well known, were far from experiencing a pecuniary overflow. Finally, it may be objected, that money will not unfrequently be lost by the capitalist from his being pressed to join in incautious speculations. All enterprise is necessarily exposed to hazard; but the probability is, that the loss will be much less to the capitalist than it at present is to the manufacturer, the latter being wholly in the dark as to the circumstances of his various debtors, while the former has evidently good means of information as to the one or the two persons whom he may chuse to entrust with his money. (D. D.)

CONCHOLOGY.

Conchology.

CONCHOLOGY is that branch of Natural History, which makes us acquainted with the form and structure of shells, enables us to classify them according to their external characters, and prepares us for the examination of the Molluscous animals to which they afford protection. It has frequently been confounded with Crustaceology, especially by the older writers on Natural History, who were in a great measure ignorant of the organization of the less perfect animals, and incapable of fixing the limits of kindred tribes. But between testaceous and *crustaceous* animals the line of separation is well defined, whether we attend to the composition of the covering, or to the structure of the contained animal. The *shells* of the former are principally composed of carbonate of lime, united with a small portion of animal matter in the form of gelatine or coagulated albumen; the *crusts* of the latter, along with animal matter and carbonat of lime, contain also a considerable quantity of phosphat of lime. The difference, however, between the two tribes, is much more strongly marked, when we examine the animals to which these coverings belong. The testaceous animals are remarkable for the softness of their bodies, the continuity of their parts, the simplicity of their mouth, and the permanency of their attachment to their calcareous dwellings. The crustaceous animals, on the other hand, have a fibrous texture, articulated members, complicated organs of mastication, and, at stated periods, renew their coverings. Testaceous bodies have likewise been confounded with the *Echinodermata* (a class which includes the sea urchins and the star-fish) not only by Aristotle, but by many modern naturalists. But the crusts with which these animals are covered, contain the same ingredients as are found in the coverings of the crustacea; and the animals themselves are furnished with prehensile tentacula. Hence they are essentially different from the testacea, and appear to be more nearly related to the Zoophytes, with which Rondeletius, and, after him, Cuvier, united them.

In taking a view of this extensive subject, we propose to confine our remarks to the consideration of testaceous bodies as objects of utility—of amusement—of scientific arrangement,—and lastly, as objects of interest to the geologist. In the body of the work the reader will find many valuable synoptical tables of the systems of different authors, and an extensive list of species, with their characters, arranged according to the Linnæan method.

Testaceous Bodies considered as Objects of Utility.

Shells as Objects of Utility.

Although testaceous bodies furnish many articles of value to man, scarcely any Conchologist has taken the trouble to enumerate the different purposes to which they have been applied, or to point out in what manner their usefulness might be increased. To the savage, shells furnish some of his most important instruments. They often answer all the purposes of a knife, and are extensively employed as a substitute for iron: with pieces of the more solid bivalves he points his arrows, and forms his fish-hooks. Even when farther advanced in civilization, the canaliculated univalves sometimes constitute the rustic lamp, while the larger scallops are employed by the dairy-maid to skim her milk and to slice her butter. From the mother-of-pearl shell many useful and ornamental articles are fabricated; and calcined shells were formerly esteemed by Physicians as absorbents; and are still regarded by the farmer as furnishing a valuable manure.

Shells thus appear to be of some importance in the arts of life; but the animals contained in these shells are of far greater value. As articles of food, shell-fish are extensively employed by the poor, and even hold a conspicuous place at the tables of the rich. In many places, they in a great measure support the children of our maritime population, and, in the Western and Northern Islands of Scotland, have, in years of scarcity, prevented the death of thousands.

Bivalves. The Oyster.

The kinds chiefly used in this country, as articles of subsistence, are bivalves, belonging to different genera. Among these the *Oyster (Ostrea edulis)* holds the most distinguished place. This shell-fish is very widely distributed in nature, being found in the seas of Europe, Asia, and Africa. But, since the days of the luxurious Romans, the oysters of Britain have been held in the highest estimation. They are found on various parts of our coasts, from the southern shores of England, to the sheltered bays among the Zetland Islands. They prefer a rough or rocky bottom, in from five to twenty fathoms water. They are fished up with a dredge and an open boat; sometimes, when in shallow water, with a rake or tongs. They are either conveyed directly to the market, or are placed in artificial ponds of sea water, where they increase in size, and acquire a fine green colour. In England this process of *fattening*, as it is termed, is chiefly conducted at Colchester, but the oysters are obtained from the little creeks between Southampton and Chichester. This fishery on the coast of England is supposed to give employment to ten thousand people, so that, independent of the addition which it makes to the articles of subsistence, it must be regarded as a valuable nursery for seamen. As an article of food, oysters are light and easy of digestion, and may be eaten in great numbers without inconvenience. They are used either raw or when pickled. In the last form, they are sent to different parts of the country, and even constitute an article of export. In Scotland, the principal oyster fishings are in the Firth of Forth; but we trust the period is not far distant, when the proprietors on the western coast of Scotland and the Hebrides will propagate this shell-fish more extensively on their shores and sheltered bays. Places fitted for their growth are every where to be met with; they require no superintending care; they would soon furnish an

Conchology. esteemed dish to their tables, and form a valuable addition to their trade.

Mussel. The next shell-fish, in point of importance as an article of food, is the *Mussel* (*Mytilus edulis*). This animal is equally widely distributed as the oyster, and is found upon our coast in the greatest abundance. It is gregarious, being found in extensive beds, which are always uncovered at low water. It is found likewise in the crevices of the rocks. In this fishery women and children are chiefly employed, and they detach the mussels with an iron hook from the beds or rocks to which they adhere by means of fine cartilaginous threads. In this country they are conveyed directly to the market; but in some places of France they are kept for a time in salt ponds, to fatten like the oyster, into which, however, they admit small quantities of fresh water. The flesh of the mussel is of a yellowish colour, and considered very rich, especially in autumn, when it is in season. It is eaten in this country either boiled or pickled, seldom in soup. To the generality of stomachs it is difficult to digest, and to many constitutions it is deleterious. It is, however, in the spring, during the spawning season, that the greatest danger is to be apprehended. This noxious quality was long considered as occasioned by the *pea crab*, which is often found within the shell of mussels. It is now with more propriety attributed to the food of the mussel, which, at certain seasons, consists chiefly of the noxious fry of the star-fish; and likewise to a disease to which the animal is subject in spring, under the influence of which it melts away, and falls from the rocks. Besides being useful to man as an article of subsistence, the mussel supplies the fisherman with one of his most convenient and successful baits. It is keenly taken both by cod and haddock. To the cod-fish, however, the animal of the horse-mussel (*Modiola vulgaris*) is more acceptable.

Cockle. The *Common Cockle* (*Cardium edule*) would deserve a place in preference even to the mussel, were it not exclusively confined to our sandy coasts and bays. It is found lodged in the sand, a few inches below the surface, its place being marked by a small depressed spot. Women and children easily dig up this shell-fish with a small spade. Cockles are sold by measure, and eaten either raw, or boiled, or pickled. They are deservedly esteemed a delicious and wholesome food in this country, although in France they are little regarded. They are in season during March, April, and May, after which they become milky and insipid. They are not generally used as a bait.

Razor-Fish. Two kinds of *Razor-fish* (*Solen siliqua* and *ensis*) are in many places of this country used as food. In Scotland they are indiscriminately termed *Spout-fish*. They are found upon most of our sandy shores, buried about a foot or two below the surface, and near to the low water mark. Their place is known by a small hole in the sand. As it is rather a laborious operation to dig them out, Bosc informs us, that the fishermen of France throw a small pinch of salt into their holes, which always remain open by the action of the respiratory organs; that they speedily rise to the surface, and are thrown out by an iron instrument made for the purpose. The fishermen believe that it is the salt which they wish to avoid; but it is conjectured, with greater probability, that the presence of the salter water, which is thus formed by the solution of the salt, makes the animal suppose that its hole is again covered with the tide. This shell-fish was esteemed by the ancients as a great delicacy. When boiled or fried, it is certainly a very palatable morsel. When kept for a few days, it forms an excellent bait for haddock or cod, and may even be employed for that purpose in a fresh state.

Myæ. Several species of *Gapers* (*Myæ*) are used as food both in Britain and on the Continent, as the *Mya arenaria*, known to the fishermen about Southampton by the whimsical name *Old Maids*. These shells reside in the mud or shingle on the shore, and a few inches below the surface. In some parts of England and Ireland, they are much used, but, though common in Scotland, they are never sought after. Another species, the *Mya truncata*, is also very common on the coast. It prefers a hard gravelly bottom, in which it lodges near low water-mark. The inhabitants of the northern islands call it *Smuoslin*, and employ it when boiled as a supper dish. It is not so delicate as some of the shell-fish which we have noticed, but it is by no means unpalatable. The *Mya declivis* of Pennant is, according to that author, very plentiful in the Hebrides, and eaten by the gentry of that country. We suspect that he should have referred to the *Mya truncata*. These shells furnish very good baits to the fisherman.

Scallops. There are several bivalve shells, besides those which we have mentioned, employed on our coasts as articles of subsistence. The *Scallop* (*Pecten*) was held in high estimation by the ancients, and still is sought after in Catholic countries. The *Pecten maximus* is frequently used in England. It is found gregarious in moderately deep water, and is taken up by the dredge. It is pickled and barrelled for sale, and esteemed a great delicacy. The fishermen suppose that they are taken in the greatest quantity after a fall of snow. Another species, the *Pecten opercularis*, is employed for culinary purposes in Cornwall, where it is known by the name of *Frills* or *Queens*. In the Firth of Forth this species is frequently dredged up along with oysters, but it is thrown, by the Newhaven fishermen, to the dunghil, along with sea urchins and star-fish. To this list we might add the *Mactra solida*, which is used as food by the common people about Dartmouth; and the *Venus pullastra*, called by the inhabitants of Devonshire Pullet, and eaten by them, and known to the inhabitants of the Northern Islands by the name of Cullyock, and there used as a bait. According to Bruguiere, the *Anomia ephippium* is used as food at Languedoc, and is there considered as preferable to the oyster.—But it is now time that we turn our attention to the univalve shells, in order to ascertain their value in an economical point of view.

Univalves. Periwinkle. The common *Periwinkle* (*Turbo littoreus*) is, in this country, more extensively used as food than any of the other testaceous univalves. This shell is easily gathered, as it is found on all our rocks which are left uncovered by the ebbing of the tide. Children

are principally employed in this fishery, and the shells are sold by measure. They are in general used after being plainly boiled, and are consumed in great quantities by the poor inhabitants on the coast. The *Nerita littoralis* is also frequently gathered along with the periwinkle, as it frequents the same situations. It is, however, much smaller, and its flesh is not reckoned equally good.

Limpet.

The *Limpet* (*Patella vulgata*) is equally abundant as the periwinkle, and frequents the same situations on the rocks. Although used by the ancients as an article of food, it is seldom brought to market in this country. Among the villages along the coast of Scotland this shell-fish is frequently used, and its juice, obtained by boiling, mixed with oatmeal, is held in high estimation. It is considered in season about the end of May. The chief excellence of the limpet, however, is as a bait. It is very easily obtained from the rocks, from which the fishermen detach it with a knife, and it is eagerly seized by all the littoral fish which are sought after. To the haddock it is very acceptable.

Snails.

Several species of *Snails* (*Helix*) are employed for culinary purposes. The largest of these, the *Helix pomatia*, was a favourite dish among the Romans, who fattened them with bran sodden with wine. They are still used in many parts of Europe during Lent, after having been fed with different kinds of herbs. This species was originally imported into Britain from Italy, and turned out in Surry, where it has readily multiplied. The *Helix hortensis* has also been employed as food. But, we believe that these two species are chiefly used medicinally, being administered in consumptive cases. The small species of the genus are the favourite food of the birds of the thrush kind, either in a wild or confined state.

Welks.

The other univalves which we shall notice are of inferior importance as articles of subsistence. The *Murex despectus*, the largest of the British turbinated shells, is frequently dredged up with oysters, and, according to Pennant, " is eaten by the poor, but oftener used for baits for cod and ray." It is probably the same species which is noticed by the Reverend William Fraser, in his view of the Parish of Gigha and Cara in Argyleshire, Vol. VIII. p. 48. *of the Statistical Account of Scotland.* He says it is a large white welk called *buckie* or dog-welk, and used as a bait for cod. The method of obtaining these shells for bait being ingenious, and making us acquainted at the same time with several new habits of the animal, we shall here insert it. " At the beginning of the fishing (says Mr Fraser) a dog is killed and singed, and the flesh, after rotting a little, is cut into small pieces, and put into creels or baskets made of hazel-wands for the purpose. These creels are sunk by means of stones thrown into them. The flesh of the dog, in its putrid state, is said to attract the welk, which crawls up round the sides of the basket, and getting in at the top, cannot get out again, owing to the shape of it, which is something like that of the wire mouse-trap. After the first day's fishing, the heads and entrails of the cod, with skate and dog-fish, are put into the creels, which are visited every day, the welks taken out, and fresh bait of the same kind put in, there being no more occasion for dogs' flesh." The *Buccinum undatum* and the *Purpura lapillus* are also employed as bait, and in years of scarcity as food.

This list of culinary shell-fish is far from complete, even in so far as it is a British list. The uses of these molluscous animals have seldom been taken notice of by Conchologists since the days of Schonvelde, more attention having been directed to the formation of new systems of arrangement, and to the discovery of new species, than to the habits and uses of those already known.

Pearls.

Independently of the food which we thus obtain from testaceous animals, they furnish us with the *pearl*, one of the most beautiful ornaments of dress. This substance, equally prized by the savage and the citizen, is composed, like shells, of carbonate of lime, united with a small portion of animal matter. Pearls appear to be exclusively the production of the bivalve testacea. Among these, all the shells having a mother-of-pearl inside, produce them occasionally. But there are a few species which yield them in greater plenty, and of a finer colour. The most remarkable of these is the *Avicula margaritifera.* This shell, which was placed by Linnæus among the mussels, is very widely distributed in the Indian Seas; and it is from it and another species of the same genus, termed *Avicula hirundo*, found in the European Seas, that the pearls of commerce are procured. The *Pinna*, so famous for furnishing a byssus or kind of thread, with which garments can be manufactured, likewise produces pearls of considerable size. They have seldom the silvery whiteness of the pearls from the Avicula, being usually tinged with brown. But the shell which in Britain produces the finest pearls, is the *Unio margaritifera*, which was placed by Linnæus in the genus *Mya*. It is found in all our alpine rivers. The Conway and the Irt in England, the rivers of Tyrone and Donegal in Ireland, and the Tay and the Ythan in Scotland, have long been famous for the production of pearls. These concretions are found between the membranes of the cloak of the animal, as in the Avicula, or adhering to the inside of the shell, as in the Unio. In the former case, they seem to be a morbid secretion of testaceous matter; in the latter, the matter seems to be accumulated against the internal opening of some hole with which the shell has been pierced by some of its foes. Linnæus, from the consideration of this circumstance, endeavoured, by piercing the shell, to excite the animal to secrete pearl; but his attempts, though they procured him a place among the Swedish nobility and a pecuniary reward, were finally abandoned; the process being found too tedious and uncertain to be of any public utility. The largest pearl of which we have any notice, is one which came from Panama, and was presented to Philip II. King of Spain, in 1579. It was of the size of a pigeon's egg. Sir Robert Sibbald mentions his having seen pearls from the rivers of Scotland as large as a bean.

Dyes.

Besides yielding us a variety of wholesome food, and valuable ornaments, testaceous animals supply us with a beautiful *dye*. The *Purpura* of the ancients, according to the opinion of Rondeletius, confirmed by the observations of Cuvier, was chiefly extracted

Conchology. from the shell termed *Murex brandaris*. Since the introduction of the cochineal insect, the use of this dye has been superseded, so that we are now in a great measure ignorant of the process which the ancients employed to extract it. In Britain there are several kinds of shell-fish, which furnish a dye of this sort, but these are seldom sought after. Cole, in 1685, published a method of obtaining it from the *Purpura lapillus*, to which Montagu, in the Supplement to *Testacea Britannica*, has added several important directions. When the shell is broken in a vice, there is seen on the back of the animal, under the skin, a slender longitudinal whitish vein, containing a yellowish liquor. When this juice is applied to linen, by means of a small brush, and exposed to the sun, it becomes green, blue, and purple, and at last settles in a fine unchangeable crimson. Neither acids nor alcalies affect its colour, and it may be conveniently employed in marking linen, where an indelible ink is desirable. The *Scalaria clathrus* (*Turbo clathrus* of Linnæus) also furnishes a purple liquor of considerable beauty, but it is destructible by acids, and gradually vanishes by the action of light. The *Planorbis corneus* likewise yields a scarlet dye, but of still less permanency than the scalaria, as all attempts to fix it have hitherto proved ineffectual.

We cannot conclude this chapter without remarking, that the study of testaceous bodies rises in importance as we perceive its utility. When we are told, that searching for shell-fish, and conveying them to the market, give employment to a British population of upwards of 10,000; that these animals furnish nourishing food to innumerable families, and in years of scarcity prevent the horrors of famine; we will be disposed to regard with a favourable eye the labours of that Conchologist, who examines the structure and economy of those animals, that, from a knowledge of their nature, he may render them still more subservient to our purposes.

Testaceous Bodies, considered as Objects of Amusement.

Shells as Objects of Amusement.

In the preceding division of our subject, we have considered testaceous bodies as applicable to various useful purposes, and expressed our regret, at the same time, that no one qualified for the task had ever bestowed on economical Conchology an attentive examination. We cannot therefore consider the present condition of the science as the result of the labours of its practical admirers. The lovers of this study, as an agreeable amusement, have at all times been numerous, from the days of Lælius and Scipio to the present time; and it is to their exertions, as collectors, that the science is principally indebted for its present state of improvement. The colours of shells are often so intensely vivid, so finely disposed, and so fancifully variegated, that, as objects of beauty, they rival many of the esteemed productions of the vegetable kingdom. In their forms they likewise exhibit an infinite variety. While some consist merely of a hollow cup or a simple tube, others exhibit the most graceful convolutions, and appear in the form of cones, and spires, and turbans; and in another division, shaped like a box, all the varieties of hinge are exhibited, from that of simple connection by a ligament to the most complicated articulation. The forms of shells are indeed so various, and many of them so elegant, that a celebrated French Conchologist warmly recommends them to the attentive study of the Architect. "Or," says Lamark, "comme l'extreme diversité des parties protuberantes de la surface de ces coquilles, ainsi que la régularité et l'elegance de leur distribution, ne laisse presque aucune forme possible dont la nature n'offre ici des examples; on peut dire que l'architecture trouveroit dans les espèces de ce genre (*Cerithium*) de même que dans celles des pleurotomes et des fuseaux, un choix de modèles pour l'ornement des colonnes, et que ces modèles seroient très dignes d'être employés." (*Annales du Mus.* Vol. III. p. 269.) In this country, however, no such recommendation is necessary, as many of our beautiful ornaments of stucco, particularly for chimney-pieces, are copied from the univalve testacea, and are greatly admired.

But shells, even with all their beauty and elegance, would never have acquired so much importance in the eyes of amateurs, had their forms been as difficult to preserve as the external coverings of the higher classes of animals. It is both a tedious and a difficult operation to preserve a quadruped, a bird, or a fish, as a specimen for the cabinet, and even when the task is completed, it is but of temporary duration. A slow but certain process of dissolution is going on, which, though invisible for a time to the owner, gradually destroys the finest collection of these objects. The very changes of the atmosphere, combined with the attacks of insects, accelerate the destructive process. But with shells the case is very different. Composed of particles already in natural combination, they do not contain within themselves the seeds of dissolution, so that for ages they remain the same. Besides, all that is in general necessary to prepare a shell for the cabinet, is merely to remove the animal. When the shell is covered with foreign matter, we must wash it away with a brush in soap and water; and it is frequently necessary to steep the shell for some time in fresh water, to extract all the salt water which may adhere to it. After being properly dried it is fit for the shelf of the cabinet, and stands in no need of anxious superintendence.

Polishing of Shells.

Amateurs are seldom contented with the simplicity of nature. Vitiated in their taste by a fashion which abides by no rules, they attempt to improve even her most elegant productions, and delight to exhibit in their cabinets some of the efforts of their art. As such are in search of innocent amusement, we mean not to dispute about the propriety of their conduct, but rather shortly to mention, for their edification, the method generally in use to improve the beauty of testaceous objects. Many shells, it is true, naturally possess so fine a polish, that no preparation is considered necessary before placing them in the cabinet. Such are the *Cypreæ*, *Olivæ*, and the greater number of what are termed *porcellaneous shells*. In general, however, it happens that, when shells become dry, they lose much of their natural lustre. This may be very easily restored, by washing them with a little water, in which a small portion of gum arabic has

Conchology.

been dissolved, or with the white of an egg. This is the simplest of those processes which are employed, and is used not only by the mere collector, but by the scientific Conchologist. There are many shells of a very plain appearance, on the outside, by reason of a dull epidermis or skin with which they are covered. This is removed by soaking the shell in warm water, and then rubbing it off with a brush. When the epidermis is thick, it is necessary to mix with the water a small portion of nitric acid, which, by dissolving a part of the shell, destroys the cohesion of the epidermis. This last agent must be employed with great caution, as it removes the lustre from all the parts exposed to its influence. The new surface must be polished with leather, assisted by tripoli. But, in many cases, even these methods are ineffectual, and the file and the pumice-stone must be resorted to, in order to rub off the coarse external layers, that the concealed beauties may be disclosed. Much address and experience are necessary in the successful employment of this last process. But it must be confessed that the reward is often great. When thus prepared, even the common mussel is most beautiful.

The arrangement of shells in a cabinet must depend, in a great degree, on the taste and fortune of the collector. If ornament is the object in view, it will be indispensably necessary to have the shells placed in glass cases, where they may be distinctly seen. But where a collection of shells is formed for amusement, they may be kept in drawers, each species placed in a paper case, or in a cup of wood, glass, or porcelain, with a label attached, intimating its name, and the place from whence it was obtained. In this manner, both univalves and bivalves may be conveniently disposed. But, as many of the former are very small in size, it is often necessary to fix them on pieces of card, that they may be preserved, and rendered easier of inspection. Perhaps the best mode of keeping these small shells, even the microscopic species, is to have a cabinet with slips of wood made to slide horizontally. These slips may be from one to three inches in breadth, and covered with white paper. Upon the middle of these the shells are fixed, with a solution of gum arabic and a little sugar, and the name marked on the edge. In many cases, when the shells are very minute, a narrow stripe of coloured paper may be fixed along the middle of the slip, to which the shells are to be attached. When neighbouring species are thus brought together, they can be easily examined with a lens. As a convenient and neat and useful method of keeping the smaller univalves, the writer of this article can recommend it from experience. It may be used with equal advantage by the botanist to preserve the smaller *Lichens*.

About the end of the sixteenth century, many individuals began to form collections of testaceous bodies. The first museum of this kind, of any consequence, was begun by Benedict Ceruto, and afterwards augmented by Calceolari. An account of the specimens contained in it was published by Olivi, in 1585, and, in 1622, Chiocco published plates of the shells. After this period, in proportion as collections of testaceous bodies became numerous, various works on shells made their appearance. These were not published for any scientific object, but merely to teach collectors the names of the different specimens in their museums. As works of this sort, we may mention the *Historia Naturalis* of Johnston—the *Gazophylacium Naturæ* of Petiver—the *Amboinsche Rariteitkamer* of Rumphius—and the *Wondertoonel der Nature* of Vincent. Nay, to this list we might add many modern works, which are termed Systems of Conchology.

From the labours of this class of Conchologists the science has derived many important advantages. A taste for the study has been widely extended; the shells of distant countries and shores have been brought together; and numerous engravings of these bodies have been published. In this manner, the labours of the man of science have been greatly facilitated, and our knowledge of nature enlarged.—But it is time that we pass from the consideration of testaceous bodies, as objects of utility and amusement, to attend to the different methods which have been employed in their scientific arrangement.

Testaceous Bodies, considered as Objects of Scientific Arrangement.

Shells as Objects of Scientific Arrangement.

Naturalists have pursued a variety of plans in their examination of this department of zoology, and have presented us with systems of arrangement founded on very different principles. Some Conchologists have attended solely to the form and structure of the shell, and have overlooked the organization of the animal inhabitant. A few have made the habits of the animal the groundwork of their systems. Others have passed over the appearances which the shells exhibit, and have confined their attention exclusively to the form and structure of the contained animal. Lastly, there have been a few who, embracing all the circumstances connected with the shell, the animal, and its habits, have constructed systems at once natural and convenient. In the following sections we propose to consider these four classes into which Conchologists may be divided.

Section I.—*Systems constructed from Circumstances connected with the Characters of the Shell.*

The arrangement of testaceous bodies according to their forms, is unquestionably the most obvious and the most ancient method. It was first employed by Aristotle, the father of Natural History, and even to the present day, its admirers are warm in its praise. It is with great propriety termed the *artificial method*, because the characters employed have no relation to any of the functions of animal life.

The Philosopher whose name we have now mentioned, had the merit of forming the divisions of Μονόθυρα, or univalves, and Δίθυρα, or bivalves. He separated the turbinated univalves from such as have but an imperfect spire, and formed many genera, or rather families, which still retain the names which he imposed.

The science of Conchology made little progress for many ages after Aristotle had published his method of arrangement. Indeed, the first work of this class which merits attention, is the *Dictionarium Ostracologicum* of Major, which was published in

1675. To him we are indebted for the threefold division of shells into *univalves*, *bivalves*, and *multivalves*, and for an explanation of the terms then employed by Conchologists.

In the same career, but with more brilliant success, Langius followed, and, in 1722, published his *Methodus nova Testacea Marina in suas Classes, Genera et Species distribuendi.* The following character is given of this work by the intelligent and industrious authors of the *Historical Account of Testaceological writers.* (*Linn Trans.* Vol. VII. p. 156) "After having noticed a multitude of mere describers, we now come to an author who is not undeserving of the title of a scientific one, and whose system, so far as marine *testacea* are concerned (and of these alone he treats), certainly glances at the great clue to simplicity, which was afterwards so successfully and admirably seized by the great reformer of natural history in general." But Langius deserves more praise than is here bestowed upon him. Before his system appeared, the characters of the genera depended principally on the *outline*, and were of uncertain application. He remedied the defect, by directing the attention of Conchologists to the form of the mouth in univalves, and to the structure of the hinge in bivalves. Among the former, he constituted subdivisions of those *ore superius aperto*, *ore superius in canaliculum abeunte*, and *ore superius clauso*. Among the latter. the circumstance did not escape him, that some of these shells are *equivalve*, others *inequivalve;* some *equilateral*, others *inequilateral*. Hence he may be considered as the founder of the inferior divisions of the artificial method, and as having furnished, to modern Conchologists, many useful hints, of which they have availed themselves, without, however, acknowledging their origin.

Another important improvement was effected by Breynius in his *Dissertatio Physica de Polythalamiis*, 1732, 4to. This consisted in separating from the ordinary univalves, such shells as possess a cavity divided by partitions into several compartments, and in forming them into a division, which he termed *Polythalamium*. These shells are now called Multilocular.

The system of Tournefort, which was published by Gualtieri, in his *Index Testarum Conchyliorum quæ adservantur in Musæo Nicolai Gualtieri, Philosophi et Medici, Florentini*, 1742, well deserves an attentive perusal. In his observations on the bivalves, he drew the attention of Conchologists to an important character, and one of easy application, having observed that, in some genera, the valves do not close or unite all round, but that, at certain places, the shell remains in part open. Such shells, in modern language, are said to *gape*.

The system of the celebrated Linnæus, which ought now to be mentioned, is too well known in this country to deserve particular notice. In many of the other departments of Zoology he effected the most important alterations; but his attempts to reform the science of Conchology, were far from being equally successful. To the subject he never was much attached, nor does he appear to have availed himself sufficiently of the labours of those authors whom we have mentioned, and of others who preceded him. The primary divisions which he employed, were those which Major had established, and his genera, with a few exceptions, were those in common use. His merit as a Conchologist rests entirely on the accurately defined terms,—the concise specific characters,—and the convenient trivial names which he employed and introduced. The particular consideration of the Linnæan genera, and the subsequent changes which have been introduced into them, will form the subject of a separate section.

For some time after the publication of the *Systema Naturæ*, the illustrious Swede enjoyed a very dangerous reputation. All his arrangements were regarded as of such high authority, that it was considered impious to attempt to introduce any change; so that Conchology, according to the artificial method, remained a long time stationary. At last in France, a country which refused to submit to the fetters of the Linnæan school, several new systems were proposed, which had for their object the restoration of those well founded genera, which Linnæus, in his too great desire to simplify, had suppressed, and the accommodation of the divisions of the science to those new relations which a more extensive knowledge of species had discovered. In this number Bosc stands eminently conspicuous In his work entitled *Histoire Naturelle des Coquilles, des Vers et des Crustaces*, and in the conchological articles of the *Dictionnaire d'Histoire Naturelle*, he has favoured the world with a detail of his system, the outline of which we shall here present to our readers:

I. Coquilles Multivalves.

1. Les unes n'ont point de charnière.

Oscabrion — Balanite
Anatif

2. Les aûtres en ont une.

Pholade — Anomie
Taret — Calceole
Fistulane

II. Coquilles Bivalves.

I. Equivalves.

1. A charnière sans dents.

Pinna — Mouïe
Modiole — Anodonte

2. A charnière garnie des dents.

A. A une dent. — Lutraire
Mulette — Petricole
Crassalette — Venericarde
Paphie — Solen
Mactre — Capse
B. A deux dents. — Sanguinolaire
a. Simple — *b.* Avec dessurnumeraires.
Trigonie — Isocarde
Tridacne — Donace
Hyppope — Cyclade
Cardite — Telline

Venus

C. A quatre dents.

Bucarde
Meretrice
Lucine

D. A beaucoup de dents.

Nucule
Petoncle
Arche
Cucullee

II. Inequivalves.

1. A charnière sans dents.

Acarde	Peigne
Radiolite	Lime
Vulselle	Houlette
Marteau	Cranie
Huitre	Hyale
Avicule	Linqule

2. A une dent.

Came	Corbule

3. A deux dents.

Spondyle	Pandore
Plicatule	Terebratule
Placune	Calceole

4. A plusieurs dents.

Perne

III. Coquilles Univalves.

I. Uniloculaires.

1. Sans spirale.

A. En Calotte.

Patelle
Oscane

B. En Tube.

Vermiculaire
Silicaire
Arrosoir

2. En spirale.

A. L'ouverture entière et sans canal à sa base.

Carinaire	Helice
Haliotide	Volvaire
Sigaret	Bulle
Stomate	Jacinthe
Argonaute	Turritelle
Concholepas	Cyclostome
Nerite	Bulime
Natice	Sabot
Helicine	Toupie

B. L'ouverture echancrée et canaliculee à sa base.

Cerite	Vis
Pyrule	Pourpre
Rocher	Volute
Rostelaire	Ovule
Strombe	Tarrière
Buccin	Porcelaine
Casque	Cone

II. Multiloculaires.

Nautile	Turrilite
Orbulite	Baculite
Ammonite	Spirule
Planulite	Orthocère
Camerine	Hippuirte
Rotulite	Belemnite.

In this system which we have exhibited, the arrangement is more methodical, and the genera are more definite, than in the Linnæan system. It unquestionably holds the first rank in the modern artificial methods.

There is a class of writers whose labours deserve some notice in this place. We allude to those who have devoted their attention to the very minute shells, so common among the sand on every sea-coast. These are too small to be examined by the naked eye, and from the instrument employed in their investigation, they are usually termed *Microscopic shells.* Plancus, in his work, *De Conchis Ariminensibus minus notis*, published in 1739, may be considered as the first who drew the attention of Conchologists to these nearly invisible objects. J. F. Hoffman, in his *Dissertatiuncula de Cornu Ammonis nativo Littoris Bergensis in Norvegia*, published in the *Transactions of the Electoral Academy of Mentz*, 1757, and in his essay *de Tubulis Vermicularibus Cornu Ammonis referentibus*, ibid. 1761, made us acquainted with various species of minute nautili produced on the northern shores. Nor did those discoveries fail to excite interest in this country. Boys and Walker devoted their attention to the subject, and gave to the world the result of their labours, in a thin quarto, entitled *Testacea Minuta rariora nuperrime detecta in arena littoris Sandvicensis*, London, 1784. Other observers, equally ardent and successful, have increased our knowledge of the forms of these minute bodies, particularly Soldani, who, in his *Testaceographia ac Zoophytographia parva et microscopica*, 1789 and 1795, exhibited many figures of the minute shells of Portoferrara, &c. The late Mr Adams described the minute species which he observed on the coast of Pembrokeshire, in the third and fifth volumes of the *Transactions of the Linnæan Society of London*, and other species of British growth have been investigated by the author of *Testacea Britannica.* We shall close this list with noticing the *Testacea Microscopica aliaque minuta ex generibus Argonauta et Nautilus ad Naturam Picta et Descripta*, Vienna, 1798. It is the joint production of L. A. Fichel and J. P. C. A. Moll, and merits an attentive perusal.

We are aware that such microscopic investigations are regarded by some Conchologists as useless, so that the minute species are excluded from their systems. But it is surely a strange method of proceeding in natural history, to judge of the merits or importance of species from their size. It is true that we are still ignorant of the inhabitants of those shells, and may long continue to be so; but our present knowledge of these has enabled us to fill up many blanks, to preserve some new relations, and even to draw some important conclusions.

That this sort of inquiry has in many instances been injudiciously conducted, all who are acquainted with the subject must admit. Due care has not been taken to distinguish these minute testacea from the fry of the larger shells, so that the number of species has been very injudiciously multiplied. These remarks apply to several figures of Walker, and to a still greater number of those of Adams.

Conchology.

Section II. *Systems constructed from Circumstances connected with the Habits of the Animal.*

Systems founded on the Habits of the Animal.

The authors of the preceding class have laboured to bring to perfection the artificial system of Conchology, and have formed their arbitrary characters, independent of the habits of life of the contained animal. But the naturalists whom we have now to consider, have traced these animals to their lurking places, and arranged them according to the situation in which they reside, instead of the forms which they exhibit.

At the head of this class of Conchologists Dr Martin Lister stands preeminently conspicuous. His great work, entitled *Historia sive Synopsis Methodica Conchyliorum*, was begun in 1685, and completed in 1692. It will long remain a monument of the extensive information and unwearied diligence of its author. The following synoptical view of the work will enable our readers to comprehend its plan; the original should be consulted with care.

Lib. i. De Cochleis terrestribus.
- Pars 1. De Buccinis terrestribus.
- Pars 2. Cochleæ nudæ terrestres Limaces quibusdam dictæ.

Lib. ii. De Turbinibus et bivalvibus aquæ dulcis.
- Pars 1. De Turbinibus.
- Pars 2. De Testaceis bivalvibus fluviatilibus.

Lib. iii. De Testaceis bivalvibus marinis.
- Pars 1. De Testaceis bivalvibus, imparibus testis.
- Pars 2. De Testaceis bivalvibus, paribus testis.
- Pars 3. De Testaceis multivalvibus.

Lib. iv. De Buccinis marinis quibus etiam vermiculi, dentalia et patellæ numerantur.

The plan followed by Sir Robert Sibbald in his *Scotia Illustrata* is somewhat different from that of Lister. He divides the Testacea into two classes, land and water shells, and the latter class he subdivides into fluviatile and marine. His inferior divisions are destitute of precision, and the number of his species limited.

The system of D'Argenville, which was so much esteemed and so long followed in France, is essentially the same with that of Lister in the higher divisions. The plan is indeed so simple, and in appearance so natural, that it has met with many admirers. It has even been useful in encouraging naturalists to study particular departments of the science, when they were prevented by their situation from devoting their attention to the whole. It is probably to this circumstance that we are indebted to Schröter for his observations on the land shells in the neighbourhood of Thangelstadt, and on the river shells of Thuringia.

The preceding arrangements, formed according to the situations in which the animals reside, and not according to their external coverings, may be considered as the first attempts at a natural method in Conchology. They serve as an introduction to a new class of authors, whose views may be considered as of a higher order, and to whose labours we shall devote our attention in the following section.

Conchology.

Section III. *Systems constructed from Circumstances connected with the Form and Structure of the contained Animal.*

Systems founded on the Form and Structure of the Animal.

The first attempt, of any consequence, to arrange testaceous animals according to the soft parts of their bodies, was made by Adanson, in his *Histoire Naturelle du Senegal*, published at Paris in 1757. In this system, the ancient classes of Univalves, Bivalves, and Multivalves, are employed under the titles les Limaçons, les Conques, and les Conques Multivalves.

Classe I. Les Limaçons.

Sect. I. Les Limaçons Univalves.

Fam. 1. Les limaçons univalves qui n'ont ni yeux ni cornes.

Fam. 2. Les limaçons univalves qui ont deux cornes, et les yeux placés à leur racine et sur leur côte interne.

Fam. 3. Les limaçons univalves qui ont quatres cornes, dont les deux exterieur portent les yeux sur le sommet.

Fam. 4. Les limaçons univalves, qui ont deux cornes et les yeux placés à leur racine, et sur le côte externe, ou pas derrière.

Fam. 5. Les limaçons univalves qui ont deux cornes et les yeux posés un peu au dessus de leur racine et sur leur côte externe.

Sect. II. Les Limaçons Operculés.

Fam. 1. Limaçons operculés qui ont deux cornes, avec un renflement, et qui portent les yeux ordinairement au dessus de leur racine, et à leur côte externe.

Fam. 2. Limaçons operculés qui ont deux cornes sans renflement, et les yeux placés à leur racine, et sur leur cote externe.

Fam. 3. Limaçons operculés qui ont quatres cornes, dont les deux exterieur portent les yeux sur leur sommet.

Classe II. Les Conques Bivalves.

Fam. 1. Les conques bivalves qui ont les deux lobes du manteaux separés dans tout leur contour.

Fam. 2. Les conques bivalves dont les deux lobes du manteau forment trois ouvertures sans aucun tuyau.

Fam. 3. Les conques bivalves dont les deux lobes du manteau forment trois ouvertures, dont deux prennent la figure d'un tuyau assez long.

The presence or absence of an operculum or lid, gives rise, in this system, to a division of the univalves into two sections, and the families are established from circumstances connected with the number of the tentacula, and the number and position of the eyes. The families among the bivalves, are arranged according to the structure of their cloak or external covering. In the class of multivalves, which we have omitted in the table, the characters are taken from the form and structure of the shell.

The work of Geoffroy, entitled, *Traité sommaire*

des Coquilles tant fluviatiles que terrestres, qui se trouvent aux environs de Paris, 1767, is constructed upon the principles of Adanson. Here, however, the objects were not sufficiently numerous to admit of all the subdivisions of that author, but he has made the form of the animal subservient to the construction of generic characters.

After these attempts to classify the animals which inhabit shells had been made in France, the celebrated Zoologist of Denmark, O. F. Müller, turned his attention to the same subject. In the *Zoologia Danica*, which contains his digested views of the subject, he employs, in the construction of his genera of univalves, the characters first used by Adanson; but among the bivalves, besides the form of the tubes or syphon, he notices the construction of the branchiæ and the presence or absence of a foot.

To our knowledge of the animals which inhabit bivalves, Poli, in his *History of the Shells of the Two Sicilies*, made very important additions. In the construction of his families, which are six in number, he employs merely the characters furnished by the syphon and foot. In the first family the animal has two syphons and a foot; in the second, there is only one syphon and a foot; in the third, a syphon and no feet; in the fourth there is an abdominal syphon and no feet; in the fifth there is a foot but no syphon; while, in the sixth, neither foot nor syphon can be discovered. In the formation of his genera, Poli takes advantage of the various forms of the cloak and the branchiæ.

To the celebrated Cuvier the Conchologist is also under the greatest obligations. By applying his vast knowledge of anatomy to the examination of the molluscous animals, he has unfolded many new conformations of parts, and exhibited many unlooked for relations. The vast collection of objects, the spoils of all the museums of the Continent, which Paris once possessed, lay open to his inspection, and his industry appears to have been equal to the harvest which invited him to labour.

In his first attempts to classify the molluscous animals, as contained in his *Tableau élémentaire de l'Histoire Naturelle des Animaux* (1798), and his *Leçons d'Anatomie comparée* (1808–1805), he employed chiefly the characters which the preceding writers had developed, in his inferior divisions; but in his primary distinctions, he distributed the mollusca into three classes: *Cephalopoda,* having the head covered with tentacula, serving as feet: *Gasteropoda*, with the head free, the animal crawling on the belly; and *Acephala*, having no distinct head.

Some years after the appearance of this classification, Cuvier directed more of his attention to the internal structure of the mollusca, and, by means of accurate dissections, obtained a more intimate acquaintance with the organs and functions of these animals than any of his predecessors had acquired. The information which he thus gained, was communicated to the public at different periods, in the well known publication *Annales du Museum d'Histoire Naturelle de Paris*. These papers, with some additional observations, were at last published in a separate form, under the title *Mémoires pour servir à l'histoire et à l'Anatomie des Mollusques*, Paris, 1816. In the following year he published *Le Règne Animal, distribue d'après son organisation*, in which he arranged the mollusca according to his peculiar views, from characters drawn exclusively from the animal.

He divides the mollusca into six classes, which he terms *Cephalopoda*, *Pteropoda*, *Gasteropoda*, *Acephala*, *Brachiopoda*, and *Cirrhipoda*.

In the class CEPHALOPODA the body is in the form of a sack, open above, containing the branchiæ, with a distinct head, surrounded by fleshy elongations or arms, adapted for moving the body or seizing prey. Into this class, along with the Sepia of Linnæus, Cuvier has inserted the multilocular shells of his genus *Nautilus*, and the genus *Argonauta*. But it is to be feared, that our knowledge of the testaceous mollusca which inhabit the numerous multilocular shells, is too limited to enable us to assign them their true place in a natural arrangement of animals.

In the second class, termed PTEROPODA, the body is closed, the head is destitute of the long fleshy arms which distinguish the animals of the preceding division; two fin-like membranes, situated on the sides of the neck, and on which the branchial tissue is in general spread, serve as organs of motion. There is only one shell belonging to this class, viz. the Anomia tridentata of Forskaehl, now forming a part of the genus Hyalina.

The third class, which includes a great number of naked and testaceous mollusca, and to which Cuvier gives the name GASTEROPODA, from the circumstance of the belly being formed for crawling, has been subdivided into seven orders, from circumstances connected with the organs of respiration.

The first and second orders, *Nudibranches* and *Inferobranches*, consist almost entirely of genera formed from the animals which Linnæus and many others included in the genus Doris. They are naked mollusca, and are likewise destitute of any internal testaceous plate. The third order, termed *Tectibranches*, contain animals whose branchiæ, like small leaves more or less divided, are situated on the right side, or upon the back. The animals of this division possess a shell, but it is in general placed beneath the common integuments, such as the genus *Aplysia* and several species of the genus *Bulla*. In the fourth order, termed *Pulmones*, which breathe air, he has constituted two divisions, the terrestrial and the aquatic. The animals of the former live on land, and were included by Linnæus in his genera Limax and Turbo. They are the land shells of most authors. Those of the division, termed aquatic, live in the water, but require, at intervals, to come to the surface to obtain fresh air. They constitute, with a few exceptions, the fresh water shells of naturalists. The *Pectinibranches* form the fifth order, and are distinguished by the branchiæ, which are like leaves or threads placed parallel in one, two, or three lines, on the surface of the pulmonary cavity. It includes the whole of the marine species of the Linnæan genera of turbinated univalves. Into this order Cuvier, from the consideration of other characters, has inserted the genus *Cyclostoma*, which, according to the characters indicated by the respiratory organs, belongs to the Pulmones.

In the sixth order, termed *Scutibranches*, the branchiæ are similar to those of the preceding order, but the sexes are united, each individual being capable of impregnating or being impregnated. The shells in general are cup-shaped, and destitute of a lid. It includes the genus Halyotis, and many species of the old genus Patella. In the last order, called *Cyclobranches*, the branchiæ appear in the form of small leaves or pyramids strung round the under margin of the cloak. They enjoy a hermaphroditism similar to those of the preceding order. The species of the genus Patella which are allied to the vulgata, and the genus Chiton, are included in this order.

In the fourth class, or ACEPHALA, he includes the bivalve shells, distributing them into families, from characters nearly similar to those which we have pointed out as having been previously employed by Poli.

The fifth class, termed BRACHIOPODA, contains animals, resembling those of the preceding class in having a cloak of two lobes, but these are always open. The branchiæ consist of small leaves placed on the inner margin of each lobe. In place of a foot they have two retractile fleshy arms, which are extensile. This class includes the Patella unguis of Linnæus, the genus Terebratula and the Patella anomala of Müller.

The class *Cirrhipoda*, distinguished by the articulated filaments with which the animals are furnished, contains the species of the genus Lepas of Linnæus. The shells belonging to the Linnæan genera Serpula and Dentalium, are transferred to the class termed Annelides.

This system of the molluscous animals is unquestionably the most perfect of all those which have been published. But, with all its excellence, we must inform the reader, that many species, nay, whole genera, have their places assigned them in this natural method, merely because the shells occupied a similar position in the artificial system, the form of the inhabitants being unknown.

SECTION IV.—*Mixed Systems.*

Mixed Systems.

In this section, we shall confine our remarks to the only system of this kind of any consequence which has hitherto appeared, and which is the production of Lamark, one of the most celebrated French zoologists of the present day. The *Systême des Animaux sans Vertebres*, Paris, 1801, of this author, embraces the whole range of animals included in the classes Insecta and Vermes of Linnæus. Where treating of the Mollusca he divides them into two orders. The first, termed *Cephalous*, from possessing a head, includes the univalves. The second, termed *Acephalous*, from the absence of a head, includes the bivalves. Instead of giving the outline of Lamark's system as published in the work now mentioned, we propose rather to present the reader with the abridgment of his method, as contained in his *Extrait du Cours de Zoologie*, Paris, 1812; but we anxiously look for the completion of the great work, in which he is at present engaged, *Histoire Naturelle des Animaux sans Vertebres*, where we hope to see this system rendered still more precise and useful. It is necessary to mention, that the animals are arranged according to the perfection of their organs, beginning with the most simple.

I. ACEPHALES TESTACES.

Ils sont enfermés dans une coquille bivalve, qui s'ouvre et s'articule en charnière.

A. Acéphalés monomyaires, leur coquille offre intérieurement une impression musculaire subcentrale.

a. Acéphalés ayant deux bras opposés, ciliés, et qui se voulent en spirale en rentrant dans la coquille.

1. *Les Brachiopodes.*

Lingule	Orbicule
Térébratule	

b. Acéphalés sans bras, ne se fixant point par un byssus.

1. *Les Ostracées.*

Radiolite	Huitre
Calcéole	Gryphée
Cranie	Plicatule
Anomie	Spondyle
Placune	Peigne
Vulselle	

c. Acéphalés ayant la plupart un pied propre à filer, et se fixant par un byssus.

1. *Les Byssifères.*

Houlette	Crenatule
Lime	Perne
Pinne	Marteau
Moule	Avicule
Modiole	

B. Acéphalés dimyaires, leur coquille offre interieurement deux impressions musculaires separées et laterales.

a. Coquille inequivalve.

1. *Les Camacées.*

Etherie	Coquille fixée.	Corbule	Coquille libre.
Came		Pandore	
Dicerate			

b. Coquille equivalve.

* Acéphalés lamellipédes ; leur pied est aplati et lamelliforme. Ligament exterieur, la coquille non baillante aux extrémites laterales.

† Aucune dent, ou une seule dent sur chaque valve les crochets ecorches.

Les Nayades. (Coq. d'eau douce.)

Mulette	Anodonte

†† Charnière multidentée.

Les Arcacées.

Nucule	Cuculée
Petoncle.	Trigonie
Arche	

††† Dents cardinales, grossières, et irrégulières.

Les Cardiacées.

Iridacne	Hiatelle
Hippope	Isocarde
Cardite	Bucarde

†††† Dents cardinales divergentes.

Les Conques.

Venericarde Venus Cythérée Cyprine Donace Donacille	Conques marines.	Telline Lucine Capse	Conques marines.
		Cyclade Galathe	Conques fluviatiles.

** Acephales crassipedes, leur pied est epais, souvent subcylindrique. Le ligament interieur, ou la coquille baillante aux extremites laterales.

† Ligament interieur dans une fossette.

Les Mactracees.

Erycine	Mactre
Onguline	Lutraire
Crassatelle	

†† Ligament interieur, sur une dent elargie.

Les Myaires.

Anatine	Mye

††† Ligament exterieur. Coquille sabulicoles, non terebrantes.

Les Solenacées.

Panope	Solen
Glycimère	Sanquinolaire

†††† Ligament exterieur. Coq. terebrantes, sans pieces accessoires.

Les Lithophages.

Saxicave	Petricole
Rupicole	Rupellaire

††††† Ligament exterieur ou inconnu. Coquilles terebrantes, avec une ou plusieurs pieces accessoires, distinct des valves.

Les Pholadaires.

Pholade	Clavagelle
Taret	Arrosoir
Fistulane	

II. Mollusques Cephales.

Mollusques Cephales Gasteropodes.

A. Branchies exterieur, placées sous le rebord du manteau, et disposées en serie longitudinale entre ce rebord et celui du pied. Elles ne respirent que l'eau.

Les Phyllidiens.

Pleurobranche	Ombrelle
Phylidie	Patelle
Oscabrion	Haliotoide

B. Branchies exterieures, composées d'une ou deux pieces placées au-desus du cou, sous le manteau. Elles ne respirent que l'eau.

Les Calyptraciens.

Cabochon	Calyptree
Fisurelle	Crepidule
Emarginule	

C. Branchies cachées ou couvertes, mais en saillie dans un cavite particulière. Elles ne respirent que l'eau.

Les Laplysiens.

Acere	Sigaret
Bullée	Dolabelle
Bulle	Laplysie

D. Branchies cachées dans un cavite particulière, et etendues sans saillie sur les parois de la cavite. Elles ne respirent que l'air libre.

Les Linaciens.

Onchide	Vitrine
Parmacelle	Testacelle
Limace	

Mollusques Cephales Trachelipodes.

A. Sans siphon saillant, et respirant en general par un trou. Coq. a ouverture entière, n'ayant à sa base ni canal ni veritable echancrure.

a. Ne respirant que l'air. Leur branchies sont entendues sur les parois de la cavite branchiale, sans y former de saillie.

* Tentacules cylindraces: coquille terrestre, avec ou sans opercule.

Les Colimaces.

Helix Helicelle Helicine Maillot	Quatre tentacules.	Bulime Amphibulime Agathine	Quatre tentacules
Cyclostome Vertigo Auricula	Deux tentacules.		

** Tentacules applaties: coquille d'eau douce toujours sans opercule, et dont l'animal vient respirer l'air à la surface de l'eau.

Les Lymneens.

Lymnee	Planorbe
Physe	Conovule

b. Ne respirant que l'eau. Leurs branchies forment des parties saillantes dans la cavite branchiale. Les uns sont fluviatiles, les autres marine.

* Coquille fluviatile, dont le bord gauche de l'ouverture n'imite pas une demi-cloison.

† Coquille operculée dont les bord de l'ouverture sont disunis.

Les Melaniens.

Melanie	Pirene
Melanopside	

†† Coquille operculée, dont les bord de l'ouverture sont reunis.

Les Peristomiens.

Paludine	Ampullaire
Valvee	

** Coquilles fluviatiles ou marine, dont le bord gauche de l'ouverture imite une demi-cloison. Point de columelle; un opercule.

Les Neritacées.

Navicelle, Neritine } fluviatile. Nerite, Natice } marine.

*** Coquilles marine, dont le bord gauche de l'ouverture n'imite pas une demi-cloison.

† Coquille flottante.

Janthine.

†† Des plis à la columelle.

Les Plicaces.

Tornatille Pyramidelle

††† Ouverture obronde à bords reunis.

Les Scalariens.

Vermet Dauphinule
Scalaire

†††† Ouverture evasée, à bord desunis.

Les Macrostomes.

Stomate Stomatelle

††††† Ouverture non evasée, à bord disunis.

Les Turbinacée.

Turritelle Monodonte
Phasianelle Cadran
Turbo Troque

B. A. Siphon saillant. Ils sont tous marines, carnassiers, et ne respirent que l'eau, qui parvient aux branchies par un siphon. Ouverture de la coquelle, soit canaliculée, soit echancrée ou versante à sa base.

a. Un canal plus ou moins long à sa base de la coquille ; le bord droit de l'ouverture ne changeant point de forme avec l'age.

Les Canalifères.

Cerite Pyrule
Pleurotome Fuseau
Clavatule Murex
Turbinelle Ranelle
Fasciolairè Strutholaire

b. Un canal plus ou moins long à la base de le coquille ; le bord droit de l'ouverture changeant de forme avec l'age, et ayant un sinus inferieurement.

Les Ailées.

Rostellaire Strombe
Pterocere

c. Canal nul ou tres court. Uni echancrure oblique à la base de l'ouverture.

Les Purpuriferes.

Casque Buccin
Cassidaire Concholepas
Harpe Pourpre
Tonne Monoceros
Vis Ricinule
Eburne Nasse

d. Point de canal à la base, mais une echancrure plus ou moins grande. Des plis sur le columelle.

Les Columellaires

Cancellaire Volute
Colombelle Marginelle
Mitra Volviare

e. Point de canal : tour de spire larges, comprimes, et enroules de l'axe de manière que le dernier recouvre presqu' entièrement les autres.

Les Enroulées.

Ovule Ancillaire
Porcelaine Olive
Tarrière Cone

Mollusques Cephalis Cephalopodes.

A. Testaces polythalames.

a. Coquille multiloculaire à cloisons simples : leurs cloisons simples sur les bords, n'offrent point des sutures decoupees et sinueuses, sur la parois interne du test.

* Coquille droite ou presque droite, point de spirale.

Les Orthocerées.

Belemnite Nodosaire
Orthocère Hippurite

** Coquille partiellement en spirale ; le dernier tour se terminant en ligne droite.

Les Lituolées.

Spirule Lituole
Spiroline

*** Coquille semi-discoide, à spire excentrique.

Les Cristacees.

Renulite Orbiculine
Cristellaire

**** Coquille globuleuse, spheroidale ou ovale : à tours de spirale enveloppans, ou à loges reunies en tunique.

Les Spherulées.

Miliolite Melonite
Gyrogonite

***** Coquille discoide, à spire centrale, et à loges rayonnantes du centre à la circonférence.

Les Radiolées.

Rotalie Placentule
Lenticuline

****** Coquille discoide, à spire centrale, et à loges qui ne s'etendent pas du centre à la circonférence.

Les Nautilacées.

Discorbis Nummulite
Siderolite Nautile
Vorticiale

b. Coquille multiloculaire à cloisons decoupées sur les bords. Les cloisons, sinueuses et lobées dans leur contour, se reunissent contre le parois interne du test, et s'y articulent en sutures decoupées comme de feuilles de persil.

Les Ammonées.

Amonite
Orbulite
Turrilite
Ammonoceratile
Bacullte

B. Testaces monothalames.

Argonauta

Mollusques Cephales Heteropodes.

Carinaire
Phylliroe
Firole

The authors of the first class of Conchologists which we have mentioned, employ exclusively the characters furnished by the shell, and scarcely deign to tell us that there is an animal attached to that shell The authors of our third class are anxious to keep the shell out of view, and draw their distinctions from the animal; but they have failed in the attempt. In extreme cases, the characters of the shell are resorted to in the absence of distinctions furnished by the animal.

Lamark perceived the inconvenience of separating these two modes of examining molluscous animals, and fortunately formed a very natural combination. We shall give his character of the genus Patella, as a specimen of this mixed system.

Patelle, Patella.

Coquille univalve, non spirale, ovale, ou suborbiculaire, en bouclier ou en bonnet, concave et simple en dessous, entière à son sommet, et sans fissure à son bord.

Patellier: Gasteropode à tête tronquée obliquement, munie de deux tentacules pointues. Les yeux à la base exterieure des tentacules. Les branchies placées autour du corps, sous le rebord du manteau.

In this manner the generic character is dependent equally on the shell and the contained animal, and that genus in a system is consequently not sufficiently established in which both these characters are not included. How many genera are in this imperfect state! Were the same plan followed in the description of species, everything we could wish for would be detailed; and our knowledge of the forms of molluscous bodies would approach to perfection. How much is it to be wished, that this plan of Lamark's were generally adopted in this country! Conchology would assume a new aspect, and the number of its votaries would rapidly increase.

Comparative Excellence of the Different Systems.

The reader will have perceived, in the course of the hasty review of those systems which we have enumerated, that we have refrained from making any remarks on their comparative excellence. This deficiency we now propose to supply in the following observations.

The authors that have arranged testaceous bodies, without reference to the animals that reside in them, appear to have mistaken the house for the inhabitant, and the thing formed for the being that produced it. They have torn asunder objects which are closely related, and united others which differ in structure and economy. These are necessary consequences of an artificial system, and they become more obvious in proportion as we descend in the scale of being.

The examination of shells, according to this method, may be viewed as the study of the osteology of the Mollusca. It has not for its object the investigation of living matter, but of dry bones. Nor has it any of those advantages which result from the study of the osteology of the vertebral animals. A knowledge of the bones of these animals enables us to ascertain many of their primary functions, the nature and extent of their powers of motion, and even the food on which they subsist. But our knowledge of shells merely, enables us not to say, whether the animal can crawl or swim; whether it feeds on plants or animals. The reason is obvious. All the muscles inserted upon the shell are either mere organs of adhesion, or destined to open and shut the valves. None of those muscles connected with any of the primary organs have any connection with the shell. That the shell furnishes several important characters, we readily grant; but we are here reasoning against the propriety of attending to the shell, to the exclusion of the animal, and, to this extent, our reasoning appears to be conclusive.

We are aware, that, in the other departments of natural history, the appearances which the external parts of an animal exhibit are constantly employed in the construction of orders and genera, and all the intermediate divisions. Thus, for example, the bill, feet, and feathers of birds, furnish the characters by which they are arranged in the system. Here, however, it must be observed, that the combined information yielded by these parts, makes us acquainted with the habits and organization of a bird. By means of these we can judge, and with certainty, not merely of its internal structure, but the places which it frequents, and the food which it consumes. Hence these characters may be applied with equal propriety in an artificial as in a natural method. But what opinion would we form of that Ornithologist, who could readily inform us that the cormorant has fourteen tail feathers, and the shag only twelve, but who was ignorant of the haunts of these birds, their food, and the number of their young. We might prize him as a companion in surveying a museum, but he is alike a stranger to science and nature.

Nor can we feel more respect for the student of mere shells. He may be able to tell us the number of whorls in a spiral univalve, or the form of the hinge in a bivalve; but if he knows not the nature of the organs of respiration, digestion, and reproduction of the animal to which the shell belongs, and contentedly remains in this ignorance, he has yet to learn the value of method in natural history. He cherishes with mistaken fondness the maxim of Linnæus, "Nomina nosse oportet qui rem scire velit," while he overlooks a more important object, expressed in the motto of the Linnæan Society, "Naturæ discere mores."

These remarks apply to the conchological labours of Linnæus and his followers, who have devoted their whole attention to the arrangement of the shells, without attending to the animals. We know that

some of the admirers of the Swedish naturalist presume to say, "*But our great author was not wholly inattentive to the creatures for which the beautiful and endlessly diversified receptacles that he had characterized were designed. Among the generic marks was included the name of the molluscous inhabitant; or, where the animal differed from any which had a place in other parts of his system, he described it at length.*" (Linn. *Trans.* Vol. VII. 175.) Now, to what does all this attention of Linnæus amount? In all the species which he has described, he has only noticed the animals of four of these, and in a very slight manner; and, with regard to the name of the molluscous inhabitant which he included in his generic marks, we hesitate not to say, that by this union he has betrayed carelessness. To many British ears these terms may sound harsh, but the proof of their correct application in the present instance will be abundantly evident, if we examine the references to the animals of a few of his genera. The genus Chiton is thus characterized—"*Animal Doris. Testæ plures, longitudinaliter gestæ, dorso incumbentes.*" Are we not led to conclude from this character, that the animals of the Chiton exactly resemble the animals of the Doris genus, with the addition of the shells? If this be the case, how artificial is that system which places these two genera in separate orders! Upon turning, however, to the genus Doris among his vermes mollusca, we find the following characters assigned to it—"*Corpus repens, oblongum, subtus planum. Os antice subtus. Anus postice, supra cinctus ciliis. Tentacula duo, supra corpus antice intra foramina retractilia.*" Now, the fine fringes around the anus of the Doris, which are the branchiæ of the animal, and form the essential character of the genus, are not to be found in the animals of the Chiton, whose branchiæ are in the form of little leaves placed along the margin of the body, and the anus is a simple pore.

According to the generic character of the Mya, the animal is an *Ascidia*, with the appendage of a shell. Upon turning to the genus Ascidia, we find it said "Corpus fixum, teretiusculum, vaginans. Aperturæ binæ, ad summitatem; altera humiliore." To prove the impropriety of referring the animal of the Mya to the genus Ascidia, we shall only mention, that the former has a foot, and possesses a locomotive power,—the latter has no foot, remains immoveably attached for life upon the substance to which it first adhered, and depends on the accidental bounty of the waves for all its nourishment.

The animals of nearly all the univalves are represented as belonging to the genus Limax. But, with the exception of the restricted genus Helix and Bulimus, the animals of the univalves are all generically different from the Limax. Their tentacula are generally two in number, with the eyes at the base; while the tentacula are four in the Limax, with the eyes at the tips of the two longest. These examples will suffice to establish a truth so palpably obvious.

The principal objection against this system of employing the shell, to the exclusion of the animal, arises from the fact, that nature has not drawn a line of distinction between the mollusca and the testacea. Thus, many of the vermes mollusca of Linnæus include shells in their bodies, as the *Aplysia*; and many of his vermes testacea likewise are soft on the outside, the shell being inclosed by the integuments, as the *Helix Haliotoidea*.

We have another objection to this artificial system, and one which we consider of great force; that, wherever it prevails, the form and habits of the animal are overlooked. How fully is this truth illustrated in the works of the Testaceologists of this country! We might examine all their writings, from the *Pinax* of Merret to the *Descriptive Catalogue* of Maton and Racket, including the works of Pennant, Berkenhout, Da Costa, and Donovan, and learn little more, besides the *habitat*, than that to every shell there is an animal attached. Of this charge the names of Lister and Montagu stand acquitted. The former has given us several good dissections, and the latter minute descriptions, of the testaceous animals.

While, in the preceding remarks, we have objected to all arrangements taken exclusively from the characters of the shell, we also disapprove of those systems founded exclusively on the characters of the animal. By the former class of methodists, the simplicity of nature is sacrificed to their peculiar views, and, by the latter, practical utility is disregarded. Devoting their whole attention to the animal, the latter Conchologists have overlooked the house in which it resides,—the roof which shelters it from the blast,—and the walls which guard it from its foes. The former Conchologists possessed very limited views of nature, and erected systems obviously artificial. To the systems of the latter, the same objections will apply. Thus, for example, among the univalves of Adanson, the families are formed from the position of the eyes chiefly. That the black points which we witness at the tips or the base of the tentacula are actually eyes, we readily admit; but what influence has these eyes on the habits of the animal? or rather, does a change of position of these organs occasion a corresponding change in the habits of the animal? Unless this is answered in the affirmative, we must consider such characters as equally artificial with any employed by Linnæus or his followers, since they have no relation to any of the primary functions of life.

The employment of characters taken exclusively from the animal is attended with so many practical difficulties, that it never can be introduced into general practice. If we find a shell thrown ashore, the animal may be dead, or it may refuse for a time to display its organs, and prevent us from arriving at its name and history. This defect, however, is partly remedied when we can call to our aid the characters furnished by the shell.

Another objection against this method arises from the well known difficulties attending the preservation of the molluscous animals. To dry them, destroys their form and texture; to inject them, is impracticable; and when put into spirits of wine, they generally appear a shrivelled mass. But the coverings of these animals are durable, and, since they form a part of the animal,—since they are produced at first along with it, increase by the addition of new matter from its body, and continue attached to it for life,—we

must condemn any classification from which the shell is excluded.

From these remarks, it will be obvious, that we consider the mixed system as the most natural and the most useful. It possesses all the advantages to which the other systems lay claim, while it is free from their defects. It withdraws part of our attention from the shell, because it is destitute of peculiar vessels, and possesses no vital energy, to fix it on those organs of the animal which are subservient to its existence. It leads us to examine the whole animal, instead of certain parts of it merely, and has a tendency to excite us to become acquainted with the manners of a tribe, from which, imperfect and artificial systems have hitherto withdrawn our attention.

It is of the utmost importance in the formation of any arrangement of natural bodies, to have an exact idea of the relative value of the characters used, and of their true subordination. This is a subject of vast moment, and too little attended to by naturalists. We do not here consider that character as of the highest kind, which is the most general, but that which has the greatest influence over the faculties and instincts of the animal. Had this subject been studied with greater care, the science of Conchology would, at this period, have been in a more flourishing condition. To ascertain, in some degree, this subordination of character, is the object of the following observations.

The division of the testaceous mollusca into three orders, as adopted by Linnæus, is confessedly artificial. The Multivalvia of that author possess no characters in common, neither can they boast of a general resemblance. The first genus, *Chiton*, consists of animals which belong to the cephalous and gasteropodous mollusca. The animals of the genus Lepas approach more nearly to the crustacea than the mollusca; while the animals, inhabiting the genus Pholas, belong to the acephalous mollusca, and are closely connected with the Myæ and Solenes. The shells of the first genus are merely calcareous scales, arranged transversely on the back of the animal. The shells of the second genus are variously articulated, fixed, and either sessile or pedunculated. The shells of the third genus are bivalves, with a few accessory calcareous plates. It is to be hoped that modern Conchologists will avoid so incongruous a combination.

The two remaining divisions of Linnæus, the bivalves and univalves, are not only obvious, but natural. They indicate the existence of certain forms peculiar to the animals whose shells are thus separated in the system. The univalve shells are inhabited by animals which possess a head, and whose organs of motion are either tentacula, situated on the head, or a foot spread over the belly, as in the slug. The animals of the bivalve shells, on the other hand, are destitute of a head; some of them have no locomotive power; and, in others, the organ of motion is a fleshy foot, which the animal can protrude at pleasure. These circumstances point out the connection which subsists between the organs of the animal, and the external forms of the shell; a connection which, in every system, ought to be carefully attended to.

It is somewhat difficult to point out, among the univalves, the true subordination, or relative importance of the characters employed by Conchologists in describing them. We have much to learn of their anatomy, and hence we cannot with certainty point out the relation of the parts of the shells to the organs which those parts protect. The form and structure of the mouth, however, may be expected to furnish characters of the first-rate importance, and have always attracted the notice of the student of testaceous bodies. The very shape of the animal, together with its ordinary habits, must necessarily depend, in a great measure, on the form of the mouth.

In many genera, the mouth of the shell towards the base is produced, and terminates in a groove or beak. These univalves are termed *canaliculated*, and are readily distinguished from those whose mouth is *entire*. The differences in the form of the shell in these two divisions is an index of equally remarkable differences in the form of the animals. The canaliculated shells contain animals possessed of an elongated tube for the purposes of respiration, and this canal is destined for its reception and protection when expanded. The animals whose shells are destitute of this canal, are likewise destitute of this lengthened respiratory tube. Circumstances of this kind induce us to believe, that shells, agreeing in external form, in general, contain animals of a similar organization. We consider this division of the univalves into canaliculated and entire, as obvious and natural.

The next character, in point of importance, appears to depend on the direction of the revolutions of the spire. In general, when a spiral univalve is placed upon its base, or mouth, with its summit towards the observer, the mouth will open on the right side of its axis or pillar, and the whorls will be observed to revolve from right to left, beginning at the base, and ending at the summit. These shells are termed *dextral*. In a few shells, however, this order is reversed. The mouth occurs on the left side of the pillar in the above-mentioned position, and the whorls from the mouth to the summit revolve from left to right. Shells of this sort are termed *sinistral*, sometimes also heterostrophe or heteroclite, and are generally called by dealers *unique*.

In the *dextral shells*, the animals have the external openings of the rectum, penis, and uterus, on the right side of the body, and the heart on the left. In the *sinistral shells*, these organs are placed on the opposite sides. Thus the openings of the rectum and organs of generation are on the left side, while the heart is situated on the right. Here again we have an external character impressed on the shell, which indicates certain arrangements in the organs of the animals. We are aware that some Conchologists consider the sinistral shells as accidental varieties, and on that account regard the character which is indicated as of inferior importance. Bosc, indeed, says, " La cause de cette variation dans la direction des spires, vient des circonstances dans lequelles s'est trouvé l'animal au moment de sa naissance, et d'un obstacle qu'il a trouvé lorsqu'il a voulu tourner sa tête du côté que la nature lui a indiqué." This explanation might have been received, had such changes

in the direction of the whorls been confined to one individual or two, of particular species. But when we observe all the individuals of particular species, nay even of genera with their whorls thus invariably reversed, we are disposed to regard the occurrence as connected with the primary structure of the animal, and not as the result of accident. Besides, the viscera of the animal of a reversed shell are not placed in the same position in relation to its back or belly, as the animals of the dextral species. A simple change of direction in the spire, therefore, will not convert a dextral into a sinistral species, and the character must be considered as of a higher order than those employed for the separation of the species merely. We consider sinistral shells as belonging to distinct genera from those which are dextral, it being inexpedient to make use of the character for higher divisions.

Among many of the univalves, the animal is furnished with a lid, by means of which it can close up the entrance of the shell after it has withdrawn itself into the cavity. It is in general corneous, sometimes also calcareous. It is usually flat, and attached to the superior and posterior part of the foot of the animal. The shells which possess this lid are generally termed *operculated shells*. They must not be confounded with those land shells whose animals form a temporary covering to the mouth, previous to winter, for the purpose of protecting them from the vicissitudes of the weather. This, in the former, is permanent, in the latter deciduous; in the former it adheres to the animal; in the latter only to the margins of the mouth of the shell.

This character was first employed by Adanson in the construction of the second section of his class univalves, and has been more or less attended to by succeeding Conchologists. It is certainly a very general character, and at first sight might be supposed worthy of forming some of the higher divisions. It appears but rarely in the land shells, more frequently in fresh water shells, and generally in the marine species. It does not, as yet, appear to be connected with any peculiar organization, although it must influence to a certain extent the economy of the animal. Were we, however, to employ it in higher divisions than generic ones, some confusion would certainly arise. It would cause the separation of many genera which are nearly allied, and even divide several natural families. Thus, for example, among the porcellaneous shells, it would separate the *olives* from the *cones*, the former being destitute of an operculum, while the latter possess one. These two genera, however, belong to a natural family, the animals of both genera having a respiratory tube upon the head, and the eyes placed on the sides of the tentacula, instead of being situated, as in the other gasteropoda, on the tips or at the base. This circumstance is calculated to convince us of the necessity of caution in the admission of characters. These may at first appear to be of extensive occurrence, and well adapted for the formation of families, but unless they exercise some visible influence on the animal, they can never be employed with propriety in a natural system, however convenient they may be in an artificial arrangement. Operculated shells may be considered as generically different from those which are destitute of that organ, without any injury to the natural method. It would even, in many instances, be convenient.

Among univalve shells, considerable differences are observable in the shape and position of this cavity. In some this cavity is simply conical, while in others it is conico-tubular, either revolving horizontally round a centre, or spirally twisted upon an axis or pillar. These circumstances furnish characters of great importance in an artificial system, as by means of them all testaceous bodies may be arranged into two tribes, the one possessing a pillar, round which the tube of the shell is twisted, while the other is destitute of any pillar. The former have been termed *Stulidia*, the latter *Astulidia*. As a natural character, however, these distinctions are of inferior importance, and, if employed, would occasion a separation between the genera Planorbis and Lymnæa, which are demonstrated by Cuvier to be nearly related. In the formation of genera, it may be employed with advantage, even in a natural system, aided by the structure of the pillar, and the direction of the whorl.

The last character which we have to notice while speaking of the univalves, depends on the circumstance of the cavity being entire, or divided into chambers, being *unilocular* or *multilocular*. In the multilocular testacea there are a number of transverse plates, in some species perforated, in others entire, which cross the cavity of the shell, and, in general, divide the external cavity, in which the animal resides, from the older and smaller ones, from which it has receded. In an artificial arrangement, such distinctions may be employed with advantage, even in the formation of the primary divisions, but we entertain doubts as to the propriety of using them in a strictly natural method. We are in a great measure ignorant of the animals which inhabit the multilocular shells, yet as far as our knowledge goes, we are induced to regard the distinction as merely conventional, and as unconnected with any peculiar order of organization. Such a division may be useful in the present state of the science, and may be permitted on that account; but in proportion as our knowledge of the mollusca advances, this distinction will be deemed inexpedient. Indeed, were this division adopted, the genera Argonauta and Nautilus would be torn from each other, although they are, by Cuvier and many others, regarded as members of a family of cephalopodous mollusca. The Nautilus lacustris of Lightfoot would, in that case, likewise be separated from the genus Planorbis, with which it is very closely allied. In the meantime, until our knowledge of the multilocular testacea arrives at a greater degree of perfection, such divisions may be employed as convenient, and of easy application.

The preceding remarks apply to those shells which belong to the cephalous mollusca. Among the bivalve shells, which belong to the acephalous mollusca, the characters which they exhibit are of very different degrees of importance. Here, as among the univalves, the appearance of the shell enables us to form an idea of the organization of the animal, so

so that the characters thus furnished by the shell, may be safely employed in a natural system.

The bivalve shells, in general, possess the faculty of moving from one place to another, or of attaching themselves to rocks and stones, by means of temporary threads. These are termed *free* shells. But there are others which secrete at their birth a calcareous cement, which unites the shell to the rock or stone immoveably for life. These last are known by the name of *fixed* shells. If we thus consider the difference in the economy of these two divisions of bivalves, we may reasonably expect to find corresponding differences in their organization. The free shells contain animals endowed with locomotion, and by consequence with feet. In few of the animals which inhabit fixed shells can a foot be observed. They are more simple in their organization than the free shells,—are destitute of absorbing or ejecting syphons, the place of these being supplied by holes in the duplicature of the cloak. This last distinction, however, is not peculiar to the fixed shells, although found in all of them.

Among the free shells, a very important circumstance occurs, which we have already noticed, viz. that some of these adhere to rocks and stones by means of temporary threads produced by the animal. They are termed *byssiferæ*. Independent of the utility of this power of producing threads of attachment, to the economy of the animals, the byssiferæ must possess at least three organs of which the other testaceous mollusca are destitute. The first of these is a gland for the secretion of the substance of which the threads are formed; the second, a foot so constructed as to be capable of spinning these threads and fixing them to the rocks or other bodies to which they are intended to adhere; and the third is a muscle in the animal to which the inner end of these threads may be attached, and which muscle, in general, has the power of contraction and elongation. This character, then, appears perhaps of the very highest order, so that, in a natural arrangement, we might divide the molluscous bivalves into such as spin threads of attachment, and such as do not. We must, however, confess, that the byssiferæ have scarcely any other subordinate characters in common, to warrant such an arrangement.

In general, the valves of which the shell consists close upon each other in such a manner as to leave no opening. In a few genera, however, the valves do not close upon each other at one end, and sometimes at both; the point of union being at one side or in the middle. The former are termed *close* shells, the latter *gaping* shells. The character of gaping, so very obvious in the shell, is an index of equally important distinctions which prevail in the animal. In the gapers, the syphons, or the absorbing and ejecting pipes, are two in number, and very long, and frequently united. The foot is contained in a sheath, from which it issues at the pleasure of the animal. Besides, the branchiæ are always united, and equal in length to the tubes. This character appears, therefore, equally important as the former. It has hitherto been employed in the construction of specific characters merely, rarely of genera.

When the two valves are of the same size and form, the shell is said to be *equivalve;* but when the one valve differs from the other in these particulars, the shell is said to be *inequivalve*. This character, so obvious and so commodious, is not the index of any peculiar organization of the animal. If employed in the higher divisions, it would separate closely connected genera, and destroy some natural alliances. The inequivalves, however, are for the most part irregular in their growth. The molluscous inhabitants have no lengthened syphon nor foot.

When we examine the inner surface of bivalves, we observe some spots of a different colour and lustre from the general surface. These are the places to which the muscles adhered, which connected the animal with the shell, and are termed *muscular impressions*. They are either separate and lateral, subcentral, or simple, or composite. This character was long employed by Conchologists in their specific distinctions, and sometimes in the formation of the genera. It has of late been employed by Lamark, as a character of the first importance in the division of the bivalves. He forms these shells into two sections, the first containing those shells which have the muscular impressions separate and lateral, and the second such as have only one subcentral, simple, or compound impression. However highly we respect the conchological labours of this naturalist, we cannot join with him in the present instance, and elevate a subordinate character to a primary rank. If, by muscular impressions, he means those marks impressed on the valves of the shells by the muscles which serve to close it, then his character is unconnected with any of the primary functions of the inhabitant. For is it of much consequence whether the valves be brought into contact by the action of one muscle or by the assistance of two? In so far, the character is evidently artificial, when the impressions of the adductor muscles only are employed. But he evidently uses the term in a more extensive sense, to refer to those impressions left on the shell by some of the other muscles by which the animal is attached to it. To the mere Conchologist, these marks are of a very uncertain import, and can never enable him to construct natural families, and the student of the mollusca will employ more important distinctions. If we are to take all the muscular impressions into account, the arrangement of Lamark must undergo great alterations. Let us take the common mussel as an example. It is placed by the French Conchologist in the second section, as having only one muscular impression, although no less than four muscles adhere to each valve, destined for the performance of very different functions. The largest impression, which is situated near the obtuse end of the shell and towards the posterior margin, belongs to the adductor muscle, employed in closing the valves. Connected with this impression there is a tongue shaped mark, reaching nearly to the ligament. This mark is occasioned by one of the lateral muscles for supporting the byssus, and by one of the lateral muscles of the foot. The other muscle for supporting the byssus, is inserted under the teeth which occur at the beak. There is even another mark of adhesion on the margin of the shell, irregularly denticulated, oc-

casioned by the fringed margin of the cloak, which is there united with the shell. This mark may be termed the *marginal impression*. To which of these marks then are we to attach the greatest importance? To the impression of the one adductor muscle, which is common to all shells,—to the marks of the muscle of the byssus, or to the indented mark of the fringed margin of the cloak. If we attend farther to Lamark's arrangement, we shall find the Camacea separated from the Ostreacea, although the two families possess numerous external and internal points of resemblance. We regard the muscular impressions as furnishing a convenient character for the construction of genera, and the discrimination of species, but it is not worthy to occupy so high a rank as Lamark has assigned to it.

As intimately connected with the muscular impressions, we may here notice the *ligament*. It is a horny elastic membrane, which serves to open the valves, when the adductor muscle relaxes. It is placed on the exterior margin in some shells, and is concealed in others. When external, it is stretched when the shell is closed, and when it is internal, it is compressed in similar circumstances. This character is very useful in the construction of genera, but it ought never to be employed in any of the higher divisions. It is not the index of any peculiar organization, neither does it serve to unite natural families. Lamark, without due consideration, regards it as next in importance to the muscular impressions.

The *teeth* of the hinge of bivalves, since the days of Langius, have been studied with care, and the characters which they furnish have been employed, both in artificial and natural arrangements, in the construction of the primary divisions. It would have been of some advantage to the science had Conchologists ascertained the use of the teeth, in the economy of the animal, before forming any divisions from their presence, absence, or position. They do not appear to be the index of any peculiar organization, neither can they be employed to bring together naturally allied families. The use of the adductor muscle is to close the shell; the ligament opens it; and the teeth of the hinge seem destined to modify and direct these movements. The characters furnished by these three parts of the shell, appear to be nearly of equal importance, and fit only to occupy a very subordinate place. Were the circumstances connected with the teeth of the hinge to become the foundation of the higher divisions, many natural families would be broken. Thus, the genus Anodonta, would be removed from the Unio, although they are both fluviatile, possess one long subulated foot, one syphon in the form of a hole, the summit of the cloak furnished with cirri, the branchiæ in part reunited, viviparous, carrying the young in the branchiæ. In short, it seems to be a character fit only for generic and specific distinctions.

Bivalve shells have often been divided into equilateral and inequilateral. These differences do not appear to be the signs of any peculiar character of the animal, or any of its functions. They must influence, to a certain extent, the relation between the different parts, but this influence is not sufficiently obvious. The character, thus furnished, is of an uncertain kind. It is influenced by the age of the individual, and, therefore, can only be employed with caution in specific distinctions.

The last character of the bivalves, which we shall notice, is the power which some of them possess of piercing stones and wood for the purpose of forming to themselves a retreat. These are termed *borers*. It was supposed by many that the animal secreted a liquor with which it dissolved the bodies into which it penetrated, but the sagacious Reaumur soon ascertained that the boring was performed by means of a rotatory movement of the larger valves. M. Fleurieu-Bellevue states, that the calcareous stone, in which the Rupellaria lithophaga is found, is often discoloured in the immediate neighbourhood of its recess. This may arise from other secretions of the animal, or even from the stagnant sea water in the hole, and not from the action of the phosphoric acid, or any other solvent supposed to be employed by the animal. These would act equally on the shell as on the calcareous rock. But the borers are not confined to calcareous rocks, they also lodge in slate-clay, and other argillaceous strata. This is very often the case with the Pholades. But this character can never be extensively employed, as the same species which, at one time, may be found imbedded in stone, will be observed at another seated among the roots of sea-weed, or buried among gravel.

From the preceding remarks it will appear obvious, that there are many characters furnished by the shell, which give us indications of corresponding peculiarities in the structure of the animal, and on that account ought to be employed in every natural arrangement. These characters have this circumstance to recommend them, that they are obvious and permanent. The objects which furnish them can be preserved in our cabinets, and serve to perpetuate our recollection of the appearances which the more perishable parts have exhibited.

There is yet another class of characters to be considered, very variously rated by different authors. These characters are taken from the situation in which shells are found, whether on the land, in fresh water, or in the sea.

This mode of dividing testaceous bodies has not been sufficiently attended to by Conchologists, who have, in general, condemned the plan, as founded upon an improper principle, viz. the classification of animals from the places which they frequent, instead of the forms which they exhibit. Such a mode of arranging the higher divisions of the different classes we would readily censure; but when employed in the inferior subdivisions of the testacea, we regard it as an important and a natural character. We ask the true naturalist to say, Which is the most important character, the hinge having teeth or wanting, and the animal residing in fresh water or in the sea? We anticipate with confidence the preference which would be given to the latter, although the decision might provoke a sneer in a mere collector. Nature has evidently drawn a line of separation between the three tribes, which it is not difficult to perceive.

The terrestrial testacea are destined to live on vegetable matter. Their organs of respiration are suited to the medium in which they reside. Their organs of feeling are, in general, more numerous

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than those of the fluviatile or marine shells. The tentacula of the latter seldom exceed two, while in the land shells the tentacula are, in general, four in number. The eyes are likewise differently placed; in the aquatic testacea they are situated on the head, at the base of the tentacula; whereas the eyes in nearly all the terrestrial species are placed on the tips of these organs. We might also add, that no bivalve shells are found on the land,—they belong exclusively to fresh water and to the sea.

The fluviatile shells, though destined to reside in a different medium from the terrestrial, have their organs of respiration (according to Cuvier) nearly the same, and are, therefore, compelled to come occasionally to the surface to respire. They have, in general, two flat tentacula, with the eyes placed at the base. They may, in general, be distinguished from the marine kinds, by the superior thickness of their epidermis,—their corneous colour, and semitransparency.

The marine shells are the most numerous,—the most beautiful,—and the most highly prized of all the testacea. Many of the univalves of this tribe possess a lengthened respiratory tube, with a canal in the shell for its protection,—a circumstance not observed in the fluviatile testacea. There is one circumstance which at once points out the difference in structure between the fluviatile and marine testacea: The fluviatile cannot live in salt water, nor the marine in fresh water. This fact points out an arrangement in their organization to which Conchologists ought to pay attention.

These remarks are calculated to persuade Conchologists to attend to the character furnished by the habitation of shells. In the formation of genera, it ought to be respected; in the higher divisions it would be inconvenient. The carelessness of Linnæus with regard to this character, is the principal reason why his genus Helix is such a confused and indigested mass. Were the distinction arising from habitation to be observed in the distribution of the testacea, no confusion could possibly take place. Some changes might be occasioned by it, but much practical difficulty would be avoided. Indeed, so useful is the distinction, that Conchologists, without avowing the propriety of the principle, have in many instances observed it.

Having thus taken a short view of the different characters employed by Conchologists in the arrangement of the testacea, and endeavoured to ascertain their relative importance, we shall conclude this part of the article by an application of the principles we have established, to an examination of the Linnæan genera, and to an enumeration of those genera which subsequent naturalists have formed, without, however, attempting to give a full list of such divisions, which have been multiplied beyond all bounds. We shall avoid a lengthened description of the species, as they are treated of very copiously in the body of the work. Our present object is to convey to the reader some farther remarks, illustrative of the history of the science.

Linnæan Genera.

Linnæan Genera.

1. Chiton. The only change which has taken place in this genus, of any consequence, is its transference to the naked cephalous mollusca, effected by Lamark. The inhabitants bear a near resemblance to those of the genus Patella, and belong to the order Cyclobranchia of Cuvier. The marginal ligament which connects the testaceous plates, even after the extraction of the animal, is, in fact, the margin of its cloak, and offers more certain and convenient distinctions for the distribution of the species, than the number or appearance of the valves,—a character exclusively employed by Linnæus. Eight species of this genus have been found on the British shores, which may be divided into the following sections:—1. Marginal ligament spinous, *Ch. fascicularis*. 2. Marginal ligament rough, *Ch. marginatus*, *ruber*, and *cinereus*. 3. Marginal ligament striated, *Ch. lævis* and *albus*. 4. Marginal ligament smooth, *Ch. lævigatus*. The *Ch. crinitus*, which Pennant obtained from the sea near Aberdeen, and Boys from Sandwich, is a species still involved in much obscurity, owing to the imperfection of the descriptions.

2. Lepas. This genus has undergone several important alterations since the days of Linnæus. As originally constructed by that author, it contained shells which differ widely from one another in habit and form. Bruguiere, the celebrated French Conchologist, separated the fixed shells furnished with an operculum, under the name of *Balanus*, and those which were seated on a peduncle, he retained under the generic name *Anatifer*. He thus suppressed entirely the Linnæan name of the genus. To the name of his first genus, we have no objections, but the second, though it records a curious fact in the history of popular errors, has been injudiciously selected. The name *Lepas* has been retained, by the best British writers, who have described seven species which live in our seas. These are distributed into two sections, according as the valves are five or more in number. The *Lepas anatifera*, is an example of the first division, and the *L. scalpellum* of the second.

The genus Balanus, as thus formed by Bruguiere, and represented by the Lepas balanus of Linnæus, contained nineteen species. From these, Lamark has separated the *B. diadema*, *testudinaris*, and *balanaris*, to form his genus *Coronula*. These shells are conical, and have the compartments formed into twelve areæ, six of these being depressed, and six elevated. They chiefly inhabit the skin of the whale, the base of the shell being placed in the fat. Lamark has likewise formed another genus, from two species analogous to the Coronolulæ, which he terms *Tubicinella*, and characterizes it thus: "Testa univalvis, regularis, non spiralis, tubulosa, versus basin attenuata, utrinque truncata; apertura orbiculata terminali; operculo quadrivalvi." The Lepas striata of Pennant ought also to form another genus, which might be termed *Verrula*, from the shell appearing like a wart on those bodies to which it adheres. It may be thus defined: "Shell with a thin testaceous base; sides depressed, composed of three obliquely ribbed rays. Mouth subquadrangular, closed by a two-valved lid."

M. Dufresne (*Annales du Museum*, Vol. I. p. 465.) endeavours to prove by reasoning, that these shells are formed posterior to the birth of the animal. He supposes that, when they become too small to contain the inhabitants on account of their increasing size, the old shells are forsaken, and more commodious dwellings formed, until the animal reaches its full size. Other proof, however, than what the author adduces, is necessary to render the opinion probable.

Lamark, in his *Système des Animaux sans vertèbres*, placed these shells in a separate section at the end of the bivalves, and among the acephalous mollusca. Afterwards he considered them as constituting a particular division of the crustaceous animals; and, lastly, he has assigned them a place in his new class, which he terms CIRRHIPIDES. (See article CIRRHIPIDES.)

3. PHOLAS. This very natural genus was placed among the multivalves by Linnæus, in the twelfth edition of his system. It is now united with the bivalves, the accessory plates at the hinge being regarded as of subordinate importance. In other respects, it has stood the test of modern innovation, with the exception of the genus GASTROCHÆNA of Spengler, in which the teeth are obsolete. This includes the Pholas hians of Chemnitz, and the Mya dubia of Pennant.

4. MYA. If we consider, as definite, the character assigned to this genus by Linnæus himself, we shall find that it excludes many species which differ from the *M. truncata*, at present considered as the type of the genus. In this shell, the valves gape at both extremities, the ligament is internal, and placed on a thick erect tooth in one valve, not inserted into the opposite side. As the M. vulsella of Linnæus is close at both ends, and destitute of a tooth, it has been separated from the true Myæ, and formed into a distinct genus by Lamark, under the title VULSELLA. This shell presented some difficulty to Linnæus, as he placed it at first among the *Pinnæ* and afterwards among the *Myæ*. Even Bruguiere gave it a place among the oysters.

Another genus has been formed by Lamark from the Mya siliqua of Chemn. (*Conch.* Vol. XI. p. 192, Tab. 198, fig. 1934.) He calls it GLYCIMERIS. Though nearly related to the true Myæ, by gaping at both extremities, yet it differs from them in the hinge, which is destitute of teeth, and in the ligament being external.

A new genus has been formed by M. M. Groye (*Annales du Museum*, Vol. IX.), which he terms PANOPEA, and assigns to it the following characters, " Coquille transverse, baillante inegalement au deux bouts, charnière semblable dans l'une et dans l'autre valve, ayant une callosité ou grosse dent allongée, placée en avant et sur le corselet; decurrente sur le bord interieur, relevée en arête, mousse et saillante posterieurement; une dent cardinale conique un peu comprimée et arquée, et sur le valve droit une fossette dans laquelle s'engrène la dent de la valve opposée; ligament exterieur, crochets peu protuberans, corselet large, deux impressions musculaires dans chaque valve situées vers les extremites." The type of this genus is the Myæ glycimeris of Gmelin first noticed by Aldrovandus. It is inserted among the British shells by Mr Donovan upon very slight authority. In the construction of the genus, we think, that M. Groye has acted properly, but there was no necessity surely for changing the trivial name bestowed upon it by the discoverer. He has added another species from Monte Pulgnasco in Parma. In the trivial name of this species, we consider that he has been guilty of an act of injustice. He has called it P. *Faujas*, in honour of Faujas St Fond, the zealous Professor of Geology in the Museum of Natural History at Paris. But the truth is, that it was found by M. Cortezi, Counsellor at Parma, and a successful investigator of the organic remains of that district. It ought, therefore, to have obtained the name of P. Cortezi, in honour of the discoverer, instead of the name of Faujas St Fond, who received it from M. Cortezi, and whose sole merit in the subject consisted in his bringing it in safety to Paris.

The principal error of Linnæus in the construction of this genus, consisted in the insertion of fluviatile shells among his marine species. Bruguiere readily perceived this error, and formed a new genus for their reception, which he called UNIO. The M. Margaritifera, so famous for the production of pearls, the *pictorum* and *ovalis* belong to this genus, and are all found in rivers.

The late celebrated author of *Testacea Britannica*, separated a few species which had been considered as Myæ, such as the *pubescens* and *prætenuis*, and formed for them a new genus, which he called LIGULA. Its character depends on the two broad spoon-shaped teeth at the hinge. With a little alteration, that genus might be prepared for receiving all the marine species, ejected from the genus Mya, on account of their being closed at the extremities.

There is one species among the British Myæ of Montagu, the *inequivalvis* which belongs to the genus CORBULA of Lamark. This genus was instituted to comprehend some fossil species found at Grignon, and is thus defined, " Testa bivalvis, inequilatera, subtransversa: natibus prominues incurvatis. Dens cardinalis unicus, conicus, recurvatus, teste oppositæ insertus. Ligamentum internum. Impressiones musculares duæ laterales." It contains but few recent species.

5. SOLEN. This genus has undergone few changes since the days of Linnæus. The character has been somewhat restricted, and those species have been removed, in which the external margin is a little arcuated, and the cardinal teeth articulated, and two in number, and formed by Lamark into a new genus, which he terms SANGUINOLARIA. This includes the *S. strigellatus* of Linnæus, the *S. sanguinolentus* of Gmelin, and we may add, as British species, the *S. antiquatus* and *squamosus* of *Testacea Britannica*. The animals of this genus, according to Poli, differ from the solens, in having the tubes of the syphon separate, and of unequal length and thickness. The *S. minutus* of Linnæus, found in our seas, is referred to the genus HIATELLA by Cuvier, a genus very imperfectly defined, but nearly allied to the Byssomia of the same author, which includes the Mytilus rugosus of Linnæus.

6. TELLINA. This extensive genus of Linnæus

the essential character of which is to have an anterior inflection or fold in each valve, and lateral teeth, includes many shells which differ greatly in form and habit, and which disagree even with his own definition. Hence several important improvements have taken place in the distribution of the species.

The first change in the genus of any consequence, consisted in the separation of the fluviatile from the marine species. This was accomplished by Scopoli (*Introd. ad Hist. Nat.* 397.), who bestowed on them the generic name of *Sphærium*. Bruguiere afterwards wantonly changed the name to Cyclas, and this change has been embraced by Lamark and other naturalists. We possess four British species of this genus, namely, *cornea*, *lacustris*, *amnica*, and *fluviatilis*. Montagu inconsiderately placed them among the cockles.

Another new genus of fluviatile shells, allied to the preceding, has been formed by Bruguiere and Lamark for the reception of one species. The genus is termed Galathea, and the species *G. radiata*. There are two approaching hinge-teeth in the right valve, with a cavity in front, and two distant hinge-teeth in the left, with an intermediate large grooved callosity. The lateral teeth are of considerable size. The ligament is external, and the muscular impressions are two in number, and lateral.

The *Tellina inæquivalvis* presents characters which readily distinguish it from the other species with which Linnæus placed it. The shell is inequivalve and inequilateral; the ligament is internal, and the lateral laminæ are wanting. Besides, the animal differs from the other inhabitants of the Tellinæ, and is nearly related to the Solens. Hence Bruguiere formed a new genus for its reception, which he termed Pandora.

There are several species of the genus Tellina and Venus, which Bruguiere and Lamark have formed into a separate genus called Lucina, which is thus characterized. " Testa bivalvis, æquivalvis, orbiculata, vel ovato transversa; natibus arcuatis, postice versis. Cardo dentibus cardinalibus 1. s. 2. variabilibus; lateralibus 1. s. 2. remotis, interdum subnullis." To this genus Lamark brings the *Tellina lactea* and *divaricata* of Linnæus, and the *muricata* of Chemn. (*Conch.* Vol. XI. p. 209. Tab. 199. fig. 1945-6.) together with the Venus *fimbriata*, and *Pensylvanica* of Linnæus, and the *Jamaicensis* of Chemn. (*Conch.* Vol. VII. p. 24. Tab. 39. fig. 408-9.) Cuvier, however, has restored the T. lactea to the genus Loripes, which Poli instituted for its reception.

7. Cardium. This is, perhaps, the best constructed genus which Linnæus formed. The characters are definite and obvious, and all the species are naturally allied. Hence no changes have taken place in their arrangement. The animal constitutes a new genus in the system of Poli, which he terms Cerastis.

Cuvier is disposed to constitute a new genus under the title Hemicardia, for the reception of the C. *cardissa* of Chemn., commonly called the Venus-heart cockle. The truncated appearance on the one side, and its being carinated in the middle, point out a conformation of the inhabitant different from the true cockles. Of this new genus we possess some fossil species.

8. Mactra. The ligament, in the marine bivalves, is, in general, placed on the outside, but in this genus, of which Lamark has formed his family—*Mactreacea*, the ligament is internal, and inserted in a cavity at the hinge formed for its reception. This family, as it stands at present, contains five well characterized genera.

In the restricted genus, Mactra, as represented by the M. *stultorum* of Linnæus; the shell gapes a little, and the lateral teeth are strong, and lock into each other. The shells with age arrive at a considerable thickness. The inhabitant belongs to the genus Callista in the system of Poli.

The genus Crassatella of Lamark contains shells which close exactly, and whose lateral teeth are obsolete. He describes seven fossil species, and six recent ones, viz. Mactra *glabrata*, *Encyclopédie Meth.* Tab. 257. fig. 3.; Venus *devancata* of Martini, *Conch.* VI. p. 318. Tab. 30. fig. 317-18.; and the following new species, *rostrata*, *Kingicola* (from King's Island!), *donacina* and *sulcata*, the three last discovered by Peron. The *Mactra triangularis* and *minutissima* of *Testacea Britannica*, probably belong to this genus.

The genus Erycina is composed entirely of fossil species. Lamark has assigned it the following character: " Testa bivalvis, equivalvis, inequilatera, transversa. Dentes cardinales bini, superne divergentes, cum foveola minima intermedia: laterales compressi oblongi. Ligamentum foveola cardinali insertum." From the situation of the ligament being inserted in the small space between the teeth, the pit or cavity is less than in any of the other genera. The muscular impressions are two in number.

The transverse mactræ, which gape, but are destitute of lateral teeth, such as the M. lutraria of Linnæus, compose the genus Lutraria of Lamark. The species already mentioned, the Mya *oblonga* of Gmelin, and the Mactra *hians* of Montagu, occur on our coasts; the former in great abundance at the mouths of the European rivers.

The genus Ungulina, formed by Daudin, contains only one species, existing in the cabinet of Favanne. It is uncertain from what country it came. It is a regular longitudinal shell. The hinge is formed by one small tooth between two oblique pits. The muscular impressions are two in number. It is figured in Deterville's edition of Buffon. (*Hist. Nat. des Coquil.* Tom. XX. f. 2, 3.)

Another genus established by the same author, and termed Erodona, is subtransverse, irregular, and gaping, the hinge, in one valve, consisting of one hollowed tooth, and in the other a depression between two eminences. It includes two shells from the cabinet of Favanne. It is intermediate between the Mactræ and Myæ.

9. Donax. The shells of this genus are readily known at first sight by their singular cuneiform shape. The hinge teeth are two in number, and the lateral teeth are spreading. The ligament is external, and, like the Tellinæ, it is placed on the shortest side. This is a circumstance of rare occurrence among the inequivalve testacea. The animal belongs to the genus Peronæa of Poli.

Lamark has instituted a genus nearly allied to

Conchology. the preceding, termed Petricola, the shells of which gape a little at both ends. There is one hinge tooth in one valve, and a bifid one in the other. The ligament is external; the muscular impressions are two in number; the structure of the hinge teeth, and the absence of the lateral teeth, at once distinguish this genus from the Donax and Venus. These animals are likewise peculiar in their habits. Lamark quotes the Venus lithophaga of Retzius, *Act. Acad. Tour.* Vol. III. p. 11, and the Venus lapicida of Chemn. *Conch.* X. p. 356. Tab. 172, f. 1664–5. But Lamark's genus has been again altered by Fleurieu-Bellevue, who has formed his genus Rupellaria, from the V. lithopagus of Retzius, and another species termed *striata. Mem. del Acad. de la Rochelle*, II. Tab. 2, fig. 9. In this genus the shell is transverse and inequilateral, compressed in the anterior part, and swollen behind. There are two crooked hinge teeth on each valve, one simple, the other bifid. The ligament is external, and there are two muscular impressions. The Donax irio belongs to this genus. The same author has formed two other genera of borers. The first he terms Rupicola, having a transverse inequilateral shell, a little gaping at the ends; no teeth or callosities. In an internal projection of each valve, there is a pit for the ligament. The other genus is named Saxicava. It is transverse, inequilateral, and gaping, without teeth, or callosity, or pit. The ligament is external.

10. Venus. This Linnæan genus contains so many species, that there is considerable difficulty in studying it. The formation of new genera, from its members, by diminishing their numbers, must prove highly acceptable to the student of Conchology. Lamark has succeeded so far by previously restricting the character of the original as follows: "Testa bivalvis æquivalvis, subinæquila tera. Dentes cardinales 3 in utroque valva, ad nates basi convergentibus. Ligamentum externum, nymphas labiaque obtegens." The three diverging hinge teeth constitute the essential character of the genus, so that Lamark has been able to form three other genera from different characters.

The genus Cytherea (the Meretrix of his *Système des Animaux*) is thus characterized: "Testa bivalvis, æquivalvis, subinæquilatera. Cardo dentibus duobus tribusve approximatis, basi convergentes; uno solitareo remotiuscula sub ano. Ligamentum ut in veneribus." It must be confessed that the insulated teeth under the lunule, in the absence of other characters, is obviously artificial. The following species are referred to this genus, Venus *meretrix, punctata, læta, pectinata, tigerina, chione, erycina*, &c.

The genus Venericardia, formed for the reception of some fossil species, is thus defined: "Testa bivalvis, æquivalvis, inæquilatera, extus longitudinaliter costata. Dentes cardinales sub-bini crassi obliquè secundi." The number of hinge teeth, and the longitudinal ribs, readily distinguish it from the genus Venus.

The other genus instituted by Lamark, and termed by him Capsa, has two teeth in one valve, and a bifid tooth in the other. The Venus *deflorata* of Linnæus is considered as the type of the genus.

It was in the construction of the characters of the genus Venus that Linnæus indulged in obscene allusions. It is now time that the pages of natural history were freed from such pollution. Other names, more expressive, can easily be substituted, alike advantageous to the interests of science, and the reputation of the illustrious Swede. Conchology.

11. Spondylus. The shells which Linnæus included under this head are usually denominated prickly oysters. The genus is represented by the *S. gæderopus* of Linnæus. The *S. plicatula* of the same author has been separated from the Spondyli, and placed in a new genus, under the name Plicatula. This genus differs from the former in the valves wanting ears, and in the absence of the triangular unisulcated space at the teeth of the under valve, so characteristic of the parent genus.

12. Chama. This is by no means a well constituted genus in the Linnæan system, as it includes shells possessing very different characters. It has, accordingly, undergone several important alterations. Bruguiere proceeded so far by establishing two new genera, and Lamark, following the same plan, has added three more to the number. Those shells, which now belong to the genus Chama, are irregular, inequivalve, and adhere to other bodies. The hinge contains only one thick oblique tooth. It is represented by the Chama *Lazarus* of Linnæus.

The genus Cardita, of Bruguiere, represented by the C. *variegata*, Lister, Tab. 344. fig. 84. consists of equivalve free shells, with the hinge furnished with two unequal teeth, the one situated under the beak, the other lateral, under the anterior margin.

The *Chama cor* of Linnæus appears to Lamark possessed of sufficient characters to constitute a distinct genus, which he has named Isocardia. It is an equivalve, free, regular, heart-shaped shell, with two cardinal teeth, and a separate lateral one, with separate, diverging, involuted beaks. It is an inhabitant of the British Seas.

To Bruguiere we owe the institution of the genus Tridacna, which is represented by the chama *gigas* of Linnæus, the largest shell in nature. The shell is equivalve and free. The hinge consists of two compressed teeth, and there is a gape at the lunule.

From the preceding genus of Bruguiere, Lamark has separated the Chama *hippopus* of Linnæus, and formed from it a new genus, which he calls *Hippopus*. In its hinge it resembles the Tridacna, but differs in the structure of the lunule, which in this is closed.

The genus Diceras of Lamark, which he formed from the chama *bicornis* of Bruguiere, approaches the Isocardia in appearance, but the following character which he assigns, is fully sufficient for their discrimination: "Testa bivalvis inæquivalvis, adherens: natibus conicis, maximis, divergentibus, in spiram irregularem contortis. Dens cardinalis maximus, crassus, concavus, auricularis in valvula majore. Impressiones duo musculares." It occurs only in a fossil state.

Before dismissing this Linnæan division of shells, we must notice another genus which has been added to it by Lamark, from species brought from the Indian Seas. He terms it *Etheria*, and describes its generic character in the following words: "Coquille

bivalve, inequivalve, irregulière, adherente, a crochets court, enfonces dans la base des valves et deriges de cote. Charnière sans dent; deux impressions musculaires separées et latcrales. Ligament demi-interieur, enveloppant une callosite oblongée, ct sortant en de hors par une fissure recourbée." He has described four species which are very rugged on the outside, but finely nacred within. Lamark places this genus in his family *Camacea*, but in external aspect, and in the absence of teeth, they make a near approach to the *Ostreacea*.

13. ARCA. Linnæus assimilated, under this genus, every shell the hinge of which presented numerous mutually inserted teeth. The shells which were thus united, have numerous relations, and constitute a very natural family. But in this family there are several groups of which Bruguiere formed sections and Lamark genera. The genus ARCA is now restricted to those shells in which the hinge is in a straight line, and composed of numerous small lamelliform teeth, without lateral ribs. They have obtained their name from their resemblance to a ship, when the shell is inverted. Many species of this genus gape a little at the superior margin, to enable the animal to send out those tendinous threads by which it adheres to the rocks. The A. *lactea*, *Noæ*, and *fusca*, are natives of the British Seas.

The Linnæan Arcæ, which have the hinge line broken and angular, belong to the genus NUCULA. In this genus, the beaks are contiguous, and turned a little backwards. The *Nucula nuclea*, *minuta*, *rostrata*, and *tenuis*, are found on our shores.

In the genus PECTUNCULUS, the hinge teeth are situated on a curved line, the shell is nearly orbicular, and the muscular impressions, which are two in number, form each a callous projection with a sharp margin. The Arca *pilosa* and *Glycymeris*, both natives of Britain, are referable to this genus.

In the genus CUCULLÆA, the teeth of the hinge are similar to the Arcæ, but at each extremity there are three or four transverse parallel ribs. It is represented by the Arca *cucullata* of Chemn. *Conch.* VII. p. 174. tab. 55. f. 526-528.

To the family Arcacea Lamark has added another genus, which he terms TRIGONIA. The hinge teeth in this are only two in number, diverging and compressed, but they are transversely grooved on each side. The muscular impressions are two in number in the recent species, T. *margaritacea*, but in some of the fossil shells referred to in this genus, Mr Sowerby could observe only one. This may lead to the formation of a new genus.

14. OSTREA. Linnæus, in the construction of this genus, brought together many shells totally dissimilar in form, character, and habit, and hence it has undergone great alterations in the hands of succeeding Conchologists. To associate in one genus shells which remain immoveably fixed to the rocks and stones from their birth, and which exhibit few other signs of vitality than the opening and shutting of their valves, with those which possess a locomotive power; to unite such as are irregular in their form and imbricated in their structure, with such as are of regular growth and solid texture, was surely to violate all the laws of a natural or an artificial system. Yet of such incongruous materials is the Linnæan genus Ostrea composed, which, in spite of all its imperfections, has still its admirers in this country. (See *Descriptive Catalogue, Lin. Trans.*) The first important improvement in the reformation of the genus, consisted in the separation of the *Pectens*, which was executed by Pennant, and afterwards by Bruguiere and Lamark. Since Lamark has assigned new characters to the genus Ostrea, other separations must take place. It is thus defined: "Testa bivalvis inæquivalvis, rudis adhærens; cardine edentulo. Fossula cardinalis majoris valvæ ætate crescens. Ligamentum semi-internum. Impressio muscularis unica." He divides the genus into two sections; the first having the margin of the valves simple, as the common oyster; and in the second the margins are plaited, as in the *O. crista-galli*.

In consequence of this change in the generic character, the Ostrea *malleus* of Linnæus, *Lister*, Tab. 219, f. 54., has been formed by Lamark into a new genus, which he calls MALLEUS. The shell is free, gapes a little at the beaks, produces a byssus, has no teeth in the hinge but a conical pit for the insertion of the ligament, placed obliquely on the margin of each valve. It was for a long time highly prized by collectors.

The genus PECTEN is one of the best characterized, most natural, and most beautiful, in the system. The shell is inequivalve and regular, the hinge is destitute of teeth, and the internal ligament is fixed to a triangular cardinal cavity. There are twelve species natives of our shores.

From the Ostrea *perna*, *ephippium* and *isogonum*, Bruguiere has formed the genus PERNA. The hinge is linear, and cut into a number of lengthened parallel veins, which receive the ligament. The interstices are formed into teeth, which simply oppose those of the other valve. In the anterior side of the valve, near the beaks, there is a callosity, and an opening for the byssus of the animal.

Lamark has constituted another genus, nearly allied to the Pernæ, which he styles CRENATULA. The hinge in this genus presents only a row of pits for the ligament, which makes it appear crenulated. The intermediate spaces are not formed into teeth, neither is there any callosity, or opening for the byssus. He has figured two new species, which he terms *avicularis* and *mytiloides*, and a third is the Ostrea *picta* of Gmelin, Chemn. *Conch.* VII. p. 243. tab. 38. f. 575.

Nearly related to the Pectens is the genus LIMA of Bruguiere. The species differ, however, in the ligament being in a great measure on the outside. They are all of a white colour. The Ostrea *lima* is considered as the type of the genus.

The genus PECTUM of Bruguiere differs from the preceding in the ligament being external, and attached to a long straight fissure. The Ostrea *spondiloidea* of Chemn. *Conch.* VIII. t. 72. fig. 669, 670, is considered as the type of the genus.

To this family we must add two genera, possessed of very singular characters. They have neither hinge nor ligament. The first, instituted by the celebrated Botanist, Commerson, is termed ACARDO. The valves are depressed and nearly equal, and held

together by the adductor muscle. The species at present known come from the eastern coast of Africa. The second is termed *Radiolites*, and was instituted by Lamark. It differs from the former in the form of the valves, the inferior being turbinated, and the superior convex or conical. The species occur only in a fossil state, and have been long known to geognosts under the title *Ostracites*.

15. ANOMIA. In the Linnæan system, this genus is equally faulty as the last. It contains many species, which differ greatly from one another and from the generic character. Some are found recent on our shores, while others occur only in a fossil state. Lamark, having rectified the Linnæan character of the genus, has separated many species, now grouped, into distinct genera. In the restricted genus ANOMIA, the under valve has a hole or groove near the beak, which is closed by a testaceous operculum. This appendage is fixed to rocks or stones, and has a ligament attached to it.

In the genus CRANIA, represented by the Anomia *cranolaris* of Linnæus, the under valve is pierced by three holes, which are oblique and unequal. It is much to be regretted that nothing is known concerning the animal.

Lamark has instituted the genus GRYPHÆA from the Anomia *gryphus* of Linnæus. In this genus, the inferior valve is concave, terminating in a spirally involuted beak, projecting upwards; the upper valve is small, and resembles a lid. A transversely striated pit at the hinge contains the ligament. The only recent species known is called *G. angulata*. Many species are found in a fossil state in the rocks of this country.

Among the anomiæ, Linnæus placed the shells which compose the genus TEREBRATULA, whose characters are so obvious and distinct. In this genus, which is inequivalve and regular, the beak of the larger valve is produced, and pierced with a hole, through which the ligament of adhesion passes. There is one species, the T. cranium, a native of our seas.

From the Anomia placenta of Linnæus, Lamark has formed his genus PLACUNA. The hinge is remarkable for two teeth on the one valve, placed like the letter V, the base toward the beak, and two impressions on the other valve. It occurs in the Indian Seas. The natives polish it for ornaments.

To Lamark we are also indebted for having formed the genus CALCEOLA from the Anomia *sandalum* of Linnæus. The largest valve is sandal-shaped, and has at the hinge two or three small teeth. The other valve is small, flat, semiorbicular, and resembles an operculum. It is frequent in a fossil state in Germany.

Mr Sowerby, in his valuable work on *British Mineral Conchology*, has made us acquainted with several new genera of fossil shells, which, by the older naturalists, would have been inserted in the genus Anomia. The genus PENTAMERUS is an equal-sided inequivalved bivalve, with one valve, divided by a longitudinal internal septum into two parts, the other by two septa into three parts or valve. Beaks incurved, imperforate. He has figured three species of this curious genus.

The genus PLAGIOSTOMA of Sowerby, is represented by the Pectenites *Plagiostomus* of Luid, Tab. 10, f. 639. and is thus defined: " An oblique eared bivalve, hinge destitute of teeth or internal pit. Line of the hinge straight in one valve, in the other deeply cut by an angular sinus." He gives figures of two species in his first volume, the *Gigantea* and the *Spinosa*. The former is the species of Luid.

The genus DIANCHORA is nearly related to the preceding, but in this the shell is fixed, and the attached valve has an opening in place of a beak. The other valve is beaked and eared. He describes two species, the D. *lata* and *striata*.

The Anomia *spinosa* of Linnæus probably belongs to Mr Sowerby's genus PRODUCTUS, which he thus defines: " An equilateral unequal-valved bivalve, with a reflexed, more or less cylindrical margin; hinge transverse, linear; beak imperforate; one valve convex, the other flat or concave externally." He gives figures and descriptions of seven species. It will be necessary to form many new genera for the reception of the fossil bivalve shells which are already known.

16. MYTILUS. Before proceeding to notice those new genera which have been formed from the Linnæan mytili, we may state, that the three parasitical species of the Systema Naturæ, belong to the genus Ostrea, to which they have been transferred by late authors. But improvements of a more important kind have been effected. Linnæus has associated together in this genus both fluviatile and marine shells. The former now constitute a very natural genus termed ANODONTA, of which the British rivers furnish three species, A. *cygneus*, *anatinus*, and *avonenses*. The muscular impressions are three in number.

It was easy to perceive that the Mytilus hirundo of Linnæus did not belong to the true mussels, since it is an inequivalve shell. Accordingly Lamark has constituted a new genus for its reception, which he terms AVICULA. The Mytilus *margaritiferus* of Linnæus is of this genus. Mr Sowerby, in his *Mineral Conchology*, Vol. I. p. 14, informs us, that he has recent specimens of Avicula hirundo from Marazion and from Bantry Bay.

Lamark, by restricting the characters of the genus Mytilus to include such species as have the beak terminal, has in this manner separated the transverse species to form the genus MODIOLA. The Mytilus modiolus of Linnæus is the type of the genus. It is common on the British shores, together with the Modiola *discors* and *discrepans*. We are at a loss to account for the scruples of Lamark (*Annales de Museuss*, Vol. X.) about considering this genus as byssiferous. Had he ever examined the figure of the type of the genus in Tab. 53 of *Zoologia Danica*, all his doubts would have been removed.

17. PINNA. No changes have taken place in this Linnæan genus, except that a few new species have been added. The Pinna *pectinata ingens* and *muricata* are found on our coasts.

In the course of our review of the Linnæan genera of bivalves, we have exposed some of those errors which the Swedish naturalist committed in associating discordant species under the same genus. Perhaps our examination of the univalves will make us

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better acquainted with the imperfections of that system, and dispose us to prize those improvements which subsequent naturalists have introduced.

18. ARGONAUTA. This genus, which contains but few species, is highly prized by collectors, who call the principal species by the name of Paper Nautilus. By restricting the characters of this genus, so as to embrace only those species in which the opening is interrupted by the involution of the spire, and in which the dorsal ridge is double, Lamark has been able to form the genus CARINARIA. In this the mouth is entire, and the dorsal ridge single. It is represented by the Argonauta *vitrea* of Gmelin.

18. NAUTILUS. Since the days of Linnæus, our knowledge of the *Multilocular* testacea has been greatly enlarged. He contented himself with arranging all the species with which he was acquainted under one genus, but, in consequence of modern industry, even the genera exceed the number of Linnæan species. Many recent species have been discovered by the aid of the microscope, among the sand on the sea shore, and a still greater number in a fossil state among the calcareous strata. These newly discovered kinds exhibit many different characters, and have compelled Conchologists to institute so many new genera for their reception, that the genus Nautilus of Linnæus appears rather as the head of a family or order, than as a separate genus of univalve shells. In this department the names of Bruguiere, Lamark, Montfort, Parkinson, and Sowerby, deserve respectful notice; and it is from their writings that the following remarks concerning the multilocular testacea have been extracted. The multilocular testacea may be divided into three sections: the first including those which are obviously spiral; the second, those which are produced; and the third, those which are of a globular or lenticular form. These sections are merely provisional, and are only intended to render more obvious and intelligible our notices of the genera.

1. *The spiral multilocular testacea.* At the head of this first division stands the modern genus NAUTILUS, in which the turns of the spire are contiguous, and the last whorl incloses the others. The partitions are perforated by a tube. We possess on our shores several species of this genus, of which the N. *crispus* is the most common.

In form, the genus LENTICULINA is nearly related to the former. The margin of the mouth reaches to the centre of the shell on both sides, and the partitions are destitute of a syphon. Lamark is in possession of a recent shell of this species from the sea near Teneriff.

The shells which Mr Sowerby, in his *Mineral Conchology*, has figured under the genus ELLIPSOLITHES, have the whorls conspicuous, although the mouth clasps the body whorl. But it is easily distinguished from the other genera with which it is related by its elliptical form.

The genus DISCORBIS of Lamark (formerly called by him Planulites) bears a considerable resemblance to the nautilus in form, but the whorls are all apparent, and the partitions entire. The following species of the genus nautilus of Montagu, may be inserted in this genus, viz. *crassulus*, *inflatus*, *carinatulus* *Beccarii and Beccarii perversus*. Were we acquainted with the position of this last shell in the animal, we might, on account of its sinistral whorls, consider it as belonging to a new genus. The serpula lobata and concamerata of the same author, are nearly related to the present genus. But the circumstance of their being fixed shells, would induce us to form a new genus for their reception, which we term LOBATULA.

In the genus Rotalia, the spires approach to a conical shape, and the marginated trigonal aperture is reflected towards the base of the shell. It consists of shells which are now found in a fossil state.

The Nautilus spirula of Linnæus has afforded characters for the construction of a new genus termed SPIRULA. The whorls are separate, the mouth orbicular, the partitions perforated by a tube, and the last turn of the spire prolonged in a straight line. This last character was unknown to Linnæus, who had only seen the spiral body of the shell.

The genus SPIROLINA has the last turn of the spire produced like the preceding, but the whorls are contiguous. The partitions are perforated by a tube. The Nautilus *semilituus* and *subarcuatulus* of Montagu are of this genus.

The genus LITUOLA is allied to the spirula and spirolina in the production of the last whorl. The spires of the body are contiguous, and the partitions are pierced by a number of holes.

In the preceding genera the inner walls of the cavity are simple; but in the two following, the walls are formed into joints by sinuous sutures. The first of these is the AMMONITES, including those shells which have been termed *cornua ammonis*. The origin of this name is, by some, sought for in their resemblance to the horns of a ram; by others, to their having been found near the temple of Jupiter Ammon, in Upper Egypt. By the Indians, the *Ammonites sacer* is considered as a metamorphosis of the god Vishnu, and termed by them *salgram* or *salgraman*. It is found among the pebbles of the Gandica where it joins the Ganges. In this genus the whorls are contiguous, spiral, depressed, and obvious.

The ORBULITES of Lamark differs from the ammonites in the circumstance of the last whorl embracing and concealing the others. In both the syphon is marginal. The ammonites *discus* of Sowerby appears to be of this genus.

Nearly allied to the preceding is the TURRILITES of Montfort. It is similar in internal structure, but while the shells of the former are spirally discoid, those of the present genus are spirally turreted, resembling a Turbo or Turricula. Four species are figured by Sowerby in his *Mineral Conchology*, Vol. I.

The Genus SCAPHITES, formed by *Parkinson*, possesses very peculiar characters. It commences with a depressed volution, the last turn of which, after being enlarged and elongated, is diminished and reflected inwards.

2. *Multilocular testacea with the shell produced.* It must be confessed, that the genera of this section are but imperfectly understood. The recent kinds are too small to admit of any investigation of the animal, so that we are left entirely to conjecture.

The genus Hippurites is of a conical form, and either straight or crooked. Within it is transversely chambered, and furnished with two lateral, longitudinal, obtuse, converging, ridges. The last chamber is closed by an operculum.

In the Orthocera the shell is straight or slightly bent, and conical. The chambers are distinct, and pierced with a tube. We possess on our shores many minute species of this genus.

The genus Baculites of Faujas St Fond, possesses a structure similar to the ammonites, the inner walls being articulated with sinuous sutures, and the partitions perforated. The shell is fusiform or bent into two parallel limbs. Mr Parkinson has contributed greatly to our knowledge of this genus, and has termed it *Hamites.* We prefer the name of the original discoverer to that of our English naturalist, which is very faulty. For, according to Pliny, "Hammites ovis piscium similis est."

In the Belemnites the shell is straight, conical, pointed, solid at the summit, and furnished with a lateral gutter. There is seldom more than one of the cells apparent, of a conical form, the older ones having been effaced in succession. The genus *Tuluxodes* of Guettard is not, perhaps, entitled to be considered as distinct.

The Amplexus of Sowerby belongs to this division. It is nearly cylindrical, divided into chambers by numerous transverse septa, which embrace each other with their reflected margins. It contains one species from the limestone rocks of Ireland.

3. *Multilocular testacea of a globular form.* The first genus of this section is the Miliola. The shell is composed of three or four oval cells, turning round an axis parallel to their longest diameter. Many recent species of this genus are common on our shores: they were included by Montagu in his genus Vermiculum.

In the Renulina the cells are narrow, linear, unilateral, curved into a part of a circle, and all situated on the same plane. The smallest cell forms a little arch round a marginal axis, and the others are placed contiguous to this on the same side. The species are all fossil.

The Gyrogona is a shell of a spheroidal form, composed of linear, curved, grooved, pieces, terminating in two poles. The external surface is obliquely spiral, the spires terminating at each pole. Found only in a fossil state.

The shells of the genus Nummulites are remarkable for their lenticular form. The external surface is smooth, and the cells concealed, but internally the transverse cells are disposed in a spiral discoid form. The cells are imperforate: they are the Camerinæ of Bruguiere,—the Helecites of Guettard,—and the Discolithes of Fortis. This last author supposes, that they are formed in the interior of an animal analogous to the Sepia. The same opinion may, with propriety, be entertained of many other genera of multilocular testacea. Faujas St Fond found a recent specimen of a nummulite among the fragments of the Corallina officinalis, brought from the island of Corsica.

It is probable that the genus Lagena, formed from the serpulæ *lagenæ* of Walker's *Testacea minuta Rariora,* belongs to the multilocular testacea; as in some of the species we have observed the appearances of internal divisions.

As connected with this division of the Linnæan genera, we may take notice of the British shell called by Lightfoot *Nautilus lacustris.* (*Phil. Trans.* LXXVI. Tab. 1.) The very circumstance of its being a fresh water shell, distinguishes it sufficiently from all those which we have been considering, and its other characters are likewise peculiar. The partitions are distant, and consist of three testaceous plates, not united, which leave a sufficient opening between them to allow the animal to protrude and withdraw itself. It constitutes a distinct genus, which we have termed Segmentina, from the trivial name bestowed on it by Solander, which refers to the structure of the septa. Its place in the system is next to the genus Planorbis.

These genera of multilocular shells which we have enumerated, are those which have been established with the greatest attention. Many other genera might have been enumerated, particularly those formed by Montfort, but the character given of them by Cuvier will satisfy the curiosity of the reader. When speaking of the *Conchyliologie Systematique* of that author, in reference to this subject, he says, "*Ou presque toutes les espèces et même des variétés sont erigées en genres.*"

19. Conus. This genus is so very natural, that it has undergone no changes since the days of Linnæus, except the addition of new species. That author was acquainted with thirty-five species and a few varieties; but M. Hawss communicated to Bruguière descriptions of one hundred and forty-six, from specimens existing in his own cabinet. We cannot boast of any British species.

20. Cypræa. This genus is equally natural as the former. It has undergone no change since the days of Major. The C. *Europæa* and *voluta* are found on our coasts.

21. Bulla. This genus presents to the mere Conchologist a source of great perplexity. It displays at once the absurdity of dividing the molluscous animals into testaceous and naked, since no such distinction is observable in nature. Many of the shells which were formerly included in this genus are found to be contained within the common integuments of the animal. It was this circumstance which induced Linnæus to separate the Limax and the Aplysia from the vermes testacea. Both of these have shells, but they are concealed. In imitation of the same principle, Lamark has formed a new genus among the naked mollusca, called Bullæa, for the reception of those bullæ in which the shell is concealed. The Bulla *aperta* is the type of the genus. The Bulla plumula of Montagu is another shell included in the animal, which is very closely connected with the genus *Pleurobranchia* of Cuvier. (*Annales du Mus.* V. 269.) It may be asked, Are all the other Bullæ found in similar situations, and consequently do they belong to the naked mollusca? Lamark considers, and apparently with reason, that all those which are distinctly spirally involuted, and ornamented with colours, are not entirely inclosed in the cloak of the animal, and ought therefore to

be ranged with the testaceous mollusca. How few British species does this character include? As originally constituted, the genus of Linnæus contained species of very different characters, so that many new genera have been formed. To Bruguiere, Lamark, and Draparnaud, we owe all the improvements which have taken place.

The modern genus Bulla includes those shells which correspond with the following character: "Testa univalvis, convoluta, ovato-gibbosa vel cylindracea: spira non exserta, apertura longitudine testæ, labro acuto." The B. ampulla is the type of the genus.

The genus Ovula, instituted by Bruguiere, is more nearly related to the Cyprea than to the Bulla. It differs however from the former, in the left margin of the lip being smooth; and from the latter, in the edges of the mouth being rolled inwards, and in the shell being produced at both ends. The B. *ovum* of Linnæus is the type of the genus; the B. patula of Pennant.

The Bulla terebellum has been employed by Lamark to constitute his genus Terebellum. The canal at the base of the mouth, and the truncated pillar, furnish the generic characters.

Linnæus was, for some time, uncertain where to place those shells which he at last inserted in the genus Bulla, under the trivial names Ficus and Rapa. These, with a few of the *murices* of the same author, constitute the genus Pyrula of Lamark. Its canaliculated base removes it from the Bullæ, while the short spire, the swelling of the last whorl, the smooth pillar, and pyriform shape, distinguish it from all those with which it is apt to be confounded. It is more nearly allied to the Fusus than to any other.

In the genus Achatina of Lamark, the pillar is truncated as in the Terebellum, but the base of the mouth is entire. It is represented by the Bulla achatina of Linnæus. To this genus we may refer the *Buccinum acicula* of Muller, which is found in England, and the *Helix octona* of Linnæus, erroneously considered as a native of Britain.

The preceding genera consist of species which live in the sea. The B. virginea is a terrestrial shell, and ought to form a distinct genus next the Bulinius. The B. fontinalis, hypnorum, and rivalis, reside in fresh water. They have, with much propriety, been formed into a distinct genus by Draparnaud, which he calls Physa. They are all sinistral shells, and will require further division when the form of the animal shall become the basis of generic distinction. The *fontinalis* and *hypnorum* are natives of Britain.

22. Voluta. This genus, as originally formed by Linnæus, depended, as he informs us, on the plicæ of the pillar, "volutæ genus facillime distinguitur columella plicata." But as this character belongs to many shells otherwise very different in form, succeeding Conchologists have separated many species from the genus, and reduced it within more natural limits. As it now stands, it is thus defined: "Testa univalvis, ovata, subventricosa, apice papillari; basi emarginata. Columella plicata; plicis inferioribus, majoribus, vel longioribus." The type of the genus is the Voluta *musica*.

Bruguiere removed from the Linnæan genus those species which are destitute of a groove at the base of their mouth, and of which Lamark formed the genera Auricula, Tornatella, and Volvaria. In the latter the spire is not produced; in the former it is produced. To the genus Auricula, which contains land-shells, the *V. auris-midæ* and *auris-judæ* belong. The V. *tornatilis* is the type of the genus Tornatella. In his reference to the genus Volvaria, Lamark quotes the Bulla *cylindracea* of Pennant and Da Costa, as if they were one and the same. But Pennant's shell is a true Bulla, while that of Da Costa is regarded as the Voluta *pallida* of Linnæus, and probably belongs to this genus.

In the genus Oliva, the turns of the spire are separated externally by a very distinct gutter or canal, and the pillar is obliquely striated. The *Voluta oliva* of Linnæus contains many different species of this genus, which are remarkable for the smoothness of their surface, and the brilliancy of their colours.

The Ancilla, which, like the former, is of a subcylindric form, is destitute of the groove which separates the whorls, and is characterized by an oblique callous ring at the base of the pillar.

In the genus Mitra of Lamark, the spire is pointed instead of ending in a small knob, as in voluta, and the plicæ of the pillar increase in size from the base upwards, which is the reverse in that genus. The V. *episcopalis* of Linnæus is the type of this genus, which contains many species much sought after by collectors.

In the Columbella, the shell is oval, the spire short, and the inner edge of the right lip is swollen. The *V. mercatoria* is the type of the genus.

The Marginella is very distinctly marked by the prominent callous collar which surrounds the outside of the right edge of the shell. The opening of the mouth at the base is scarcely grooved. The V. *glabella* is the type of the genus.

The Cancellaria is nearly related to the genus columbella, but the absence of the swelling of the lip, and the presence of the compressed sharp plicæ of the pillar, furnish sufficiently obvious characters of distinction. The *V. cancellata* of Linnæus is the type of the genus.

In the genus Turbinellus the shell is turbinated, subfusiform, and canaliculated at the base, having from three to five transverse compressed plicæ on the pillar. The V. *pyrum* is the type of the genus. Is not the V. *hyalina* of Montagu nearly allied to this genus?

23. Buccinum. This is another of the Linnæan genera of shells, which has undergone great alterations. As originally constructed, it embraced many distinct groups of shells, which Bruguiere and Lamark have since formed into genera. The restricted character of the genus Buccinum is thus defined by the last mentioned author: "Testa univalvis, ovata vel elongata. Apertura oblonga, basi emarginata, nudata, canali nullo. Columella convexa plana."

Bruguiere separated the genus Cassis, in which the opening is oblong and denticulated on the right side, with a short canal towards the back of the shell. The right margin has a callous border. The Buccinum *cornulum* of Linnæus is the type of the species.

The genus TEREBRA was likewise formed by the same author. It is remarkable for its turreted form, the spire being at least twice as long as the mouth, and the pillar at the base twisted. The B. *maculatum* of Lin. is the type.

In the genus NASSA the groove in which the mouth terminates is reflected as in Cassis, but the left edge of the mouth is callous, and forms upon the pillar a transverse fold. The B. arcularia of Lin. is the type.

The PURPURA is readily distinguished from the Buccinum and Murex, with which it has often been associated by its naked compressed pillar, ending in a point at the base. It includes our common littoral shell the Buccinum *lapillus*.

The genus DOLIUM is distinguished by its bellied forms and transverse rings, together with the margin on the right side being denticulated its whole length. The Buccinum *galea* of Linnæus is the type of this genus.

The genus HARPA is well known, and is distinguished by its sharp parallel longitudinal ribs. The pillar is smooth and pointed at the base.

In the genus EBURNEA, the shell is smooth, and the pillar umbilicated and subcanaliculated at the base. The Buccinum *glabratum* is the type of the genus.

24. STROMBUS. This Linnæan genus is now converted into a family, distinguished by the right margin changing its form with age, and having towards the base an indenture or sinus. It contains three genera, Strombus, Rostellaria, and Pterocera.

In the genus STROMBUS, the canal is short, the right margin is simple, and ends in a sinus. The S. *pugilis* of Linnæus is the type of this genus.

In the ROSTELLARIA the canal is produced into a long beak, the right edge of the mouth is entire, and rests above on the spire, and is sometimes decurrent. The sinus is contiguous to the canal. The R. *cornuta* of Mart. *Conch.* IV. Tab. 158. f. 1495, is the type of the species.

In the PTEROCERA the canal is also lengthened, but the right margin is dilated and digitated with a sinus near the base. The Strombus Pes-Pelicani of our shores is of this genus.

25. MUREX. The modern genus of this name is thus defined by Lamark: "Testa univalvis, ovata, vel oblonga; basi caniculata; suturis varicoso-tumidis, sub asperis, longitudinalibus, et persistentibus." In consequence of this restriction, the five following genera have been instituted.

In the genus FASCIOLARIA, the spires are destitute of those longitudinal ribs which the Murices always exhibit, while the pillar is furnished with two or three oblique folds. The Murex *tulipa* of Linnæus is the type of this genus.

The shell of the genus FUSUS is lengthened, generally fusiform, destitute of longitudinal ribs, and bellied in the middle or lower part with a smooth pillar and lengthened canal. The F. *longicauda*, Lister, Tab. 918. f. 11. A. is the type.

The PLEUROTOMA is distinguished from the preceding by a sinus or groove, which appears on the margin of the right edge of the mouth, near its summit. It is represented by the M. Babylonius of Linnæus.

The genus CLAVATULA differs from the former in possessing a short canal, and ought never to have been separated. We may refer to this the Murex sinuosus of Montagu, and M. emarginatus of Donovan.

In the genus CERITHIUM, the mouth is oblique, terminating below in a short truncated or recurved canal, and having at the upper part a gutter more or less produced. The *Tympanotonos asper* of Mart. *Conch.* 4. p. 314. Tab. 156. f. 1473, and 1474, is the type of the genus.

26. TROCHUS. This is a very natural genus in the Linnæan system, and has undergone few alterations in the hands of modern Conchologists. The T. perspectivis has given rise to a new and very obvious genus, termed SOLARIUM, characterized by the internal spiral edge of the umbilicus being crenulated. Another species, the T. *labio*, is the type of the genus MONODONTA, which contains shells of an oval form, with a rounded mouth, furnished with a tooth, formed by the truncated projecting base of the pillar: the two margins are separated. The turreted trochi of Linnæus constitute the genus PYRAMIDELLA.

The T. terrestris of British writers is so imperfectly described and figured, that it is impossible to assign it a place in the system. It is nearly allied to the helix.

27. TURBO. This very extensive genus has been greatly dismembered by modern Conchologists, in consequence of Lamark having restricted the character in the following terms: "Testa univalvis, conoïdea vel subturrita. Apertura integra rotundata, edentula; marginibus superne semper disjunctis; columella basi planulata." Our T. littoreus is a good example of the restricted genus. In noticing the new genera which have been formed, we shall begin with the marine shells.

In the genus SCALARIA, the mouth is circular and bordered, with the margins united. The spires are covered with raised, edged, slightly oblique, longitudinal ribs. The famous wentletrap is the type of the genus.

Lamark thus defines his genus DELPHINULA: "Testa univalvis subdiscoïdea vel abreviato conica, solida, margaritacea, umbilicata; anfractibus subasperis. Apertura rotundata, marginibus orbiculatim connexis." The T. *delphinus* is the type of the genus. There are many species of turbines common on our shores, which are excluded by the preceding characters from the genera Turbo and Delphinula, such as the striatus, cingellus, Bryereus and others. They are distinctly turreted, with the margins of the mouth united, and may constitute a genus to be termed CINGULA.

The Turbo terebra of Linnæus serves as the type of another genus, termed TURITELLA, in which the margins of the mouth are disjoined, the spire regularly turreted, and the lip emarginated by a sinus. Nearly allied to the preceding is the genus PHASIANELLA, which Lamark thus defines: "Testa univalvis, ovata vel conica, solida. Apertura longitudi-

nalis, ovata, integra; labro simpliei aeuto. Columella lævis basi attenuta. Opereulum ealeareum vel corneum animali adherens."

Perhaps a rigorous examination of the turbines of British writers might justify the formation of one or two new genera; yet we shall content ourselves with noticing those speeies with which we have formed the genus Odostomia, in which the columella is furnished with a tooth. The Turbo interstincta, unidentata, plieata, Sandivicensis and insculpta of Montagu, are of this genus. They have no resemblanee in their strueture to the Linnæan volutæ; although they have been ineonsiderately assoeiated with them by the authors of the *Descriptive Catalogue.* The preeeding genera are formed of marine shells; those that follow live on the land.

In the genus Cyclostoma, the mouth is eircular, with united and often refleeted margins. The animal is furnished with an opereulum. The T. *elegans* of Montagu is the only British speeies of the genus.

The speeies whieh are related to the T. bidens perversus and museorum of Linnæus, constitute a very natural family, which may be termed Pupacea, distinguished by the mouth being furnished with teeth or testaceous laminæ, and the last whorl nearly the same or less than the preeeding. Perhaps the most convenient way of dividing them is into two seetions, the first including the dextral, and the second the sinistral shells.

The dextral pupacea form two genera. The Pupa, as originally eonstrueted by Lamark, was equally faulty with many of the old Linnæan genera. As we have restrieted it to include dextral shells, with the animal possessing four tentacula, with eyes at the tips of the two longest, we can reeeive into it the *muscorum*, *sexdentatus*, *tridens*, and *juniperi* of Montagu. In the genus Carychium, formed by Muller, the tentacula are only two in number, with the eyes plaeed at the base. It is represented by the T. *carychium* of Montagu.

The sinistral pupaeea form likewise two genera. The first, which is the Clausilia of Draparnaud, contains sinistral shells, with the animal furnished with four tentacula, with eyes at the tips of the two longest. This contains the following British species,—*perversa*, *nigricans laminata biplicata*, and *labiata*. The other genus, called Vertigo was formed by Muller. The animal possesses only two tentacula, with the eyes on their tips. The T. *vertigo* is the type of the genus.

28. Helix. Linnæus, in constructing this genus, attended only to the eharaeter of the mouth being contracted or lunated, without regarding the habits of the animals, or even the other forms whieh the shells exhibited. Hence he has united globose, discoid, and turreted, terrestrial, fluviatile, and aquatic shells; animals with two and with four tentaeula, with and without an opereulum, oviparous and viviparous.

The marine species of Linnæus are few in number. The genus Janthina of Lamark, has been formed from the H. *janthina* of Linn. a species which has lately occurred at several places of the Irish coast. The opening is triangular, and there is an angular sinus at the right edge. The shell, which Linnæus terms H. *haliotoidea*, is completely concealed in the animal, and belongs to the genus Sigaretus, among the naked mollusea of Lamark. There are many marine shells inserted in the genus Helix by British writers, whieh either belong to the restricted genus Turbo, or to the Vermieularia.

The further reduction of the Linnæan heliees depends on the separation of the terrestrial from the fluviatile shells, and subdividing these according to the eharaeters furnished by the different groups.

Among the terrestrial shells, the restrieted genus Helix is by far the most extensive. It eontains those shells whieh are subglobose, with a convex spire; the opening entire, wider than long, and diminished in its upper part by the projection of the last turn but one of the spire. The animal is furnished with four tentacula, with eyes at the tips of the two longest. The *H. pomatia* is the type of the genus.

The genus Bulimus, as originally eonstrueted by Bruguiere, was faulty in the extreme, but Lamark has new modelled it so as to include those land shells which are turreted or eonical, with the mouth larger than broad, and having, in general, the margin refleeted with age. Like the Heliees, they have no opereulum, and possess four subulated tentacula. The following are known as British species, B. *obscurus*, *lubricus*, *Lackhamensis*, and *fasciata*.

From the Helix sueeinea of Muller (the putris of Montagu and Donovan, not of Linnæus) Draparnaud has formed the genus Succinea. The mouth is large in proportion to the size of the shell, and effuse at the base, with the outer lip thin, and the pillar attenuated. We are at a loss to aecount for the conduct of Lamark in substituting a new name for this genus without any apparent reason, and thus adding to the synonimes with which the science is already oppressed. The name first employed by Draparnaud, indicates one of the most striking characters of the type of the genus, whereas the term Amphibulina, used by Lamark, is founded on a mistake, and is apt to mislead. The H. succinea, although found in damp plaees, is not amphibious. It never enters the water voluntarily. Indeed, Muller says, "Sponte in aquam descendere nunquam vidi, a contra quoties eum aquæ immisi, confestim egrediebatur." The same remark is made by Montagu, and we have often witnessed its truth.

The *Helix pellucida* of Muller has been formed into a new genus by Daudebard, which he termed Helieo-limax, but which Draparnaud, to avoid the use of a hybrid name, changed for the term Vitrina. Lamark has placed it among his naked mollusea, as the shell merely covers the superior parts, and the animal is furnished with a shield.

The fluviatile shells, included by Linnæus in his genus Helix, may, for the sake of present eonvenienee, be considered as forming two seetions, viz. those with and those without an operculum. To the former belongs the very natural genus Lymnea, containing conical or turreted shells, with the right lip joined to the left at the base, and folding back on the pillar. The H. *stagnalis* of Linnæus, is the type of the genus, of which we possess ten British species. Two of these are truly amphibious, the octanfracta and fossaria.

The genus Planorbis, instituted by Geoffroy or rather by Petiver, is remarkable for its discoid form, the spire revolving nearly in a horizontal line, so that all the whorls are obvious on both sides. Cuvier observed that the P. *cornea* was a sinistral shell, and it remains to be ascertained whether the whorls in the other species have a similar direction. We possess nine British species of this genus.

The operculated divisions of fluviatile helices, is more numerous than the preceding, containing at least six genera.

The genus Valvata was instituted by Muller to include depressed shells with an orbicular mouth, the animal, furnished with three tentacula and a plumose appendage, considered as the branchiæ. The V. *cristata* (Helix crist. of Montagu), and *piscinalis* (the Turbo fontinalis of Montagu), are natives of this country.

The genus Vivipara, instituted by Geoffroy, and afterwards employed by Montfort, is represented by the H. *vivipara* of Linnæus. It is the same as the Paludina of Lamark. The shell is ovate or oblong, with a regularly elevated rounded spine. The aperture is entire, with the two lips united angularly at the summit. The type of the genus and the V. *tentaculata*, are natives of Britain.

In the genus Ampullaria of Lamark, the shell is globose, the base umbilicated, and the mouth longer than broad. The H. *ampullacea* is the type of the genus.

In the genus Helicina of Lamark, the mouth is semilunar, the pillar callous and compressed below. The H. *neritella*, Lister, *Conch.* Tab. 61, fig. 59, is the representative of the genus.

In the genus Melania of Lamark, the shells are turreted, longer than broad, effuse at the base, with a twisted solid pillar. The H. *amarula* is the type.

The genus Melanopsis was instituted by Daudebard to include the shells termed Melaniæ by Olivier in his voyage to the Levant. The mouth is lanceolate, the pillar truncated and emarginated above, with a callosity at the base.

29. Nerita. This genus has been subdivided by Adanson and Bruguiere into Nerita and Natica. In the former there is no umbilicus as in the N. *exuvia*, and, in the latter, there is an umbilicus, as in the N. *canrena*. Of the restricted genus nerita, we only possess one species, the *littoralis*, common on our shores. There are at least six species of Natica of British growth, the largest of which is the *glaucina*. The fresh water species have been formed by Lamark, with great propriety, into a distinct genus, under the title Neritina. The N. *fluviatilis* occurs in the English rivers.

30. Halyotis. This genus has been dismembered of those species which are destitute of the perforations on the disk. These have been formed into a new genus, termed Stomatia.

31. Patella. This genus, which at first sight appears so very natural, contains shells which exhibit considerable differences, both in form and structure, when narrowly examined. Geoffroy, with great propriety, separated the fluviatile species under the generic title Ancylus, a genus afterwards employed by Muller. The animal is essentially distinct from the marine patellæ. There are two species of this genus, the *lacustris* and *fluviatilis*, natives of Britain.

The genus Patella, as circumscribed by Lamark, is thus characterized: " Testa univalvis, non spiralis, clypeata vel subconica, imperforata, fissura marginali destituta cavitate simplici." The common Limpet may serve as the type of this genus.

In the genus Fissurella, established by Bruguiere, there is always an opening like a key-hole, near the summit of the shell. The *F. græca* and *apertura* are found on our coasts.

The genus Emarginula is readily distinguished by the slit or indentation which occurs on the posterior margin of the shell. Lamark conjectures that the anus of the animal is situated at the hole at the summit of the fissurella, and at the posterior slit in this genus. In the genus Capulus of Montfort, the shell is conical, with the summit produced into a beak, more or less recurved, and twisted. The P. *hungarica* of Lister is the type. Cuvier seems inclined to place in this genus the *Bulla velutina* of Müller, the *Helix lævigata* of British authors. The E. *fissura* is a native of our shores.

The genus Concholepas is furnished with an operculum, and in form and habits approaches the Buccinum. It is represented by the P. *integra* of of Da Costa's *El.* tab. 2. fig. 7.

In the genus Crepidula, the cavity of the shell is partially interrupted by a simple diaphragm. The P. *porcellana* is the representative of this genus. The C. *chinensis* inhabits the British seas.

In the preceding genus, the first approach to the turbinated shell makes its appearance, which becomes more obvious in the genus Calyptræa, in which the cavity is furnished with a spiral diaphragm. The C. *equestris* is the type of the genus, which is related in part to the Trochi. From this genus of Lamark, Montfort has separated the Infundibulum, as possessing a central spiral pillar. Sowerby has figured several species of this last genus in his *Mineral Conchology* as occurring in a fossil state in Britain.

The Patella unguis now ranks as a bivalve, and constitutes the genus Lingula in the acephalous family Brachiopoda of Lamark. Linnæus, who never saw more than one valve, placed it among the Patella. Chemnitz, who examined both valves, considered it as a Pinna. These writers had overlooked the figure of the perfect shell, with its tube or stalk, as given by Seba, Vol. III. fig. 16. No. 4. This specimen, which belonged to Seba, passed into the museum of the Stadtholder, and afterwards reached, in company with the spoils of the other Continental collections, the Museum of Paris. Here Lamark examined it, and formed his new genus. And the same specimen enabled Cuvier to investigate its anatomical structure, which he has explained in detail in the first volume of the *Annales de Museum.* Science has in this instance, as well as several others, profited by the successes of the Ex-Emperor of the French. This genus is destitute of a hinge. The valves are supported on a peduncle, and the shell is opened partly by the relaxation of the adductor muscle of the animal (and not by the external

membrane, as stated by Mr Sowerby), and partly by the issuing forth of its spiral arms, which push asunder the valves like a wedge.

Cuvier has likewise constituted a new genus, which he terms ORBICULA, from the Patella *anomala* of Müller, *Zool. Dan.* Vol. I. p. 14. t. 5. The under valve is very thin, and fixed; the upper is orbicular, and depressed. It is a member of the same family as the preceding in the system of Lamark.

32. DENTALIUM. This very natural genus of Linnæus has undergone no alterations. The Dentalium *imperforatum*, *trachea*, and *glabrum* of Montagu's *Testacea Britannica*, do not accord with the essential character of the Linnæan genus in being "utraque extremitate pervia." In consequence of this, we formed, some years ago, a new genus for their reception, called CÆCUM. They differ from the dentalia in being closed at the apex, and, in a natural arrangement, would probably be placed near the genus Vermicularia.

33. SERPULA. This genus has undergone several changes in the hands of modern Conchologists. The S *seminulum* has been transferred to the genus Miliola, and the S. *filogranum* to the Tubipora. Besides these trivial alterations, the character has been greatly circumscribed, so as only to include shells which adhere to other bodies, and are tubular, entire, and flexuous, with a simple mouth, as represented by the S. contortuplicata of Linnæus. The species which are regularly spiral, discoid, and fixed, as the S. spirorbis, now constitute the genus SPIRORBIS. But as there are both dextral and sinistral shells with this character, we propose to retain the dextral species in the genus Spirorbis, and form the genus HETERODISCA for the reception of the reversed species. Under each genus, we can rank six British species.

The genus VERMICULARIA is formed from those species which, in appearance, resemble the Spirorbis, but are not adherent, such as the S. *lumbricalis*. The shell at the mouth is, in general, somewhat produced. There are two or three minute British shells of this genus. As not very remotely connected with this genus, we may notice the EUOMPHALUS of Sowerby, which he styles "An involute compressed univalve; spire depressed on the upper part; beneath concave or largely umbilicate. Aperture mostly angular." It occurs in a fossil state.

The genus SILIQUARIA, represented by the S. *anguina*, is distinguished from the serpula by a longitudinal, lateral, subarticulated fissure, which extends the whole length of the shell.

The genus PENICILLUS is formed from that curious shell the S. *penis*, and well known by the name of the watering-pot. The disk is perforated by a number of small holes.

34. TEREDO. From this genus, now considered as a bivalve (the tube being regarded as an accessory covering), the FISTULANA, of which the T. *clava* of Gmelin is the representative, has been separated. The external tube in this genus is closed at the posterior extremity, while in Teredo it is open. The S. *polythalamia* belongs, according to Lamark, to the Fistulana.

35. SABELLA. This last genus of the Linnæan vermes testacea has been degraded from its rank in conchology. The covering consists of agglutinated particles of sand and fragments of shells, and bears no resemblance to the testaceous coverings of the true mollusca. It is now placed in company with the Terebella among the *annelides*.

In the preceding review of the Linnæan genera of shells, the reader will probably have been astonished at those changes which have taken place. In this country we are so much accustomed to the artificial method both in Zoology and Botany, that we often reject, without sufficient consideration, the improvements which the study of the natural method has suggested. In the time of Linnæus, perhaps, the genera of shells, with a few exceptions, were sufficiently numerous and commodious to embrace all the known species; but since the science has been cultivated with more zeal, in consequence, we must say, of the introduction of the natural method, the number of species has increased fourfold. New genera and orders, and other conventional divisions, have been formed, suited to the state of improvement of the science. The merit of all these improvements did not originate with Bruguiere or Lamark, whose names we have so often had occasion to mention. Many of the modern genera may be traced to the systems which prevailed before the days of Linnæus,—systems which the Swedish Naturalist, in his desire to simplify, when simplicity was impracticable, too incautiously disregarded.

ON FOSSIL SHELLS.

Fossil Shells.

Besides the shells which are found on the land, and in our lakes, rivers, and seas, and termed *recent* shells, there are relics of many species found in our marl-pits and limestone rocks, always somewhat altered in their texture, which are denominated *fossil* shells. While the shells of the former class have been eagerly sought after, few Conchologists have directed their attention to the condition or distribution of the fossil species. Nearly six hundred species of recent shells have been described as natives of Britain, while the fossil species, belonging to our strata, which have been accurately described, fall short of that number. There is, however, reason to believe, that the fossil species are more abundant.

It would have been a pleasant task for us to have entered into the details of this most important subject, but our limits permit us only to trace its outlines. Our remarks, however, we trust, will prove useful to those who are entering this fruitful field of investigation, and will embrace some observations on the systematic characters, condition, situation, and distribution, of these organic remains.

Systematic History of Fossil Shells. The determination of the characters of the fossil species of shells is attended with very great difficulty. The changes which they have undergone, and their union with the substance of the rock, prevent us from ascertaining, with any degree of accuracy, the peculiar marks by which the species are characterized. No trace of the animal remains, to aid us in the investigation, so that all our distinctions must rest on the characters furnished by the shell. This circumstance should prevent us from placing much confidence on the conclusions which have been drawn with respect to

the resemblance between fossil species, and those which still exist in a living state.

The difficulty of determining the fossil species, and the reluctance to form new genera, rendered the descriptions of the older writers nearly unintelligible, although their figures are still useful to refer to. Lamark, aware of the imperfection of the characters of the genera of recent shells, as connected with this subject, and possessing a rich cabinet of the fossil species found in the neighbourhood of Paris, devoted much time to the illustration of this subject, and with great success, as his various papers published in the *Annales du Museum*, abundantly testify. In this country, Parkinson, in his work entitled *Organic Remains of a former World*, has added some important illustrations of the genera of Lamark, and has given some good descriptions of the species found in our rocks. Mr Sowerby, in his *Mineral Conchology* (publishing in numbers), is giving to the world excellent figures of the British fossil shells; but we regret to add, that he displays too great anxiety to constitute species; and the rocks, in which they are found imbedded, are but imperfectly characterised. But as the figures are well executed, they will prove highly useful to the British Mineralogist, by enabling him to refer to them with confidence, and to give names to those species which he meets with in the course of his investigations.

Chemical History of Fossil Shells. When we consider the elements of which shells are composed, and the nature of their combination, we might be ready to expect that fossil shells would differ but little in structure from recent species. But the case is widely different. In many instances, the confused foliaceous structure which prevailed in the recent shell, has given place to a new arrangement of the particles, and the fossil shell exhibits a foliated crystalline structure. Here solution and precipitation have taken place in the same spot. In some cases the calcareous matter of the shell has become impregnated with foreign ingredients, or has totally disappeared, leaving in its place ferruginous or siliceous depositions. But the most curious circumstance in the chemical history of these fossils, is the preservation of the animal matter of the shell into its original form and order of arrangement, even when the calcareous matter of the shell has been changed into compact or granular limestone. This very important fact we owe to the ingenuity of Mr Parkinson, who, by treating the shell for a length of time with greatly diluted acid, abstracted the calcareous matter, and obtained a distinct view of the cartilaginous membranes of the shell. The student will in general observe, that the cavities of those shells, which present an external opening, are filled with the same sort of matter as the rock in which they are enclosed; while the cavities of the multilocular testacea, which have no external communication, are filled with matter invariably of a crystalline structure, even when not different from the substance of the rock.

Geognostic History of Fossil Shells. It appears evident that the advancement of this branch of Conchology must, in a great measure, depend on the accurate discrimination of the fossil species, and the relations of the rocks in which they are contained. It is only within the last twenty years, therefore, that our knowledge of this branch of the subject has been acquired. Werner has contributed largely to our stock of knowledge, but much yet remains to be brought to light. The following notices may be regarded as embracing the principal facts which have been ascertained.

In those ancient strata upon which all the others are incumbent, and which are called *Primitive*, no remains of shells, or other relics of organized bodies, have hitherto been detected. These rocks are therefore supposed to have received their arrangement previous to the creation of animals or vegetables. In that group of rocks which rests upon the primitive strata, and to which Mineralogists give the name of *Transition*, fossil shells, as well as the remains of vegetables, have been observed. The shells exhibit such striking peculiarities of form, and bear so remote a resemblance to the recent kinds, that they are considered as the remains of species which do not now exist in a living state on the globe. They are much changed in their texture, and in general intimately united with the contents of the stratum. They are chiefly found in the beds of limestone, sometimes also in the greywacke and clay state. In the numerous and ill-characterized series of strata which are incumbent on the transition class, and to which Mineralogists attach the term *Floetz*, the remains of shells are much more numerous. In the older members of this class, such as the red sandstone and independent coal formations, the shells, though generally different in form from those of the preceding class, are still dissimilar to the recent species, and no longer exist in a living state. In the newer members of this class, however, such as the gypsum and chalk rocks, the species bear a much closer resemblance to the existing races, and several species cannot be distinguished from them by any satisfactory characters furnished by the shell. The fossil species found in the rocks of the older members of the class are greatly altered in their texture, and, in many cases, intimately united with the substance of the beds; the shells belonging to the newer members, are much less altered in their form and texture, separate more readily from the surrounding rocks, and appear like recent shells somewhat weathered. The shells are found in nearly all the different kinds of rock, but are more numerous in the calcareous strata. In the *alluvial* strata, fossil shells are frequently to be met with. The species which here present themselves bear so close a resemblance to the existing kinds, that Conchologists are disposed to consider them as the relics of animals which still exist. In many cases, the prototypes may be found on the neighbouring shore or lake, but in other instances they must be sought for at a greater distance. These shells are found in beds of gravel and sand, and likewise in great abundance in shell marl.

It appears, then, that the shells in the older strata differ specifically from those which the newer strata contain; and that they have belonged to molluscous animals, which no longer exist in a living state on this globe; that, in the newer strata, the fossil shells bear a closer resemblance to existing species; and that in the last formed strata, remains of species actually existing are to be met with.

In this distribution of the remains of testaceous animals we likewise perceive that, in the older strata, the inequivalved and multilocular shells are more numerous than the other kinds; and that the canaliculated univalves are seldom to be met with in the transition or older members of the Floetz series, but that they become more numerous in the newer members of the Floetz rocks, and in the alluvial strata. Circumstances of this kind induced Werner to conclude that different formations could be discriminated by the petrifactions which they contain. From the difficulty of distinguishing the fossil species, however, joined with our ignorance of their geographical distribution, few Mineralogists have suffered their conclusions to be much influenced by this rule.

It will likewise be observed, that the shells in the newer strata are but little changed, while those in the older rocks are greatly altered in their texture, and in part obliterated. The same power which rendered the rock compact or crystalline, has likewise exerted its influence on the imbedded remains. In the newest strata, this power has scarcely begun to operate; so that the imbedded shells still retain in perfection their original characters.

In examining a limestone quarry, for example, the student will perhaps be surprised to find petrifactions of shells in the bed of limestone, while, in the sandstone covering, he witnesses impressions of plants unaccompanied with shells. In order to gain more correct ideas on this subject, let him repair to a marl bog, and he will there find the bed of marl abounding in shells, while in the bed of sand below, on which it rests, or of peat moss, which covers it, he will find exclusively the remains of vegetables. Here let him study the subject, while the strata are yet recent, and while lapidification is only commencing. There is, however, this difference between the shells in the marl and those in the limestone, that individuals of the former species still exist, while no living examples of the latter are known.

Geographical History of Fossil Shells. As the geographical distribution of recent shells is a branch of Conchology to which few have devoted their attention, and about which very little is known, we can scarcely expect to find the geographical distribution of the fossil species more fully illustrated. We know, with regard to the recent shells, that some species which are found in the bays of Norway and Greenland occur also on the shores of the Mediterranean, and that the British Isles have several species in common with Africa and the West Indies. Still we know not, with any degree of accuracy, the geographical range of any one species. Geologists ought, therefore, to exercise a great degree of caution in drawing conclusions concerning the original situation of those shells which they find in a fossil state. When a fossil shell is discovered in the strata of this country, which bears a close resemblance to the recent shells of distant seas; many inquirers, without waiting until they have established the identity of the species, and without any precise information with regard to the geographical distribution of that species, conclude that this fossil shell must have been brought from these distant seas, and conveyed to its present situation by some mighty torrent. Instances of this mode of reasoning could easily be pointed out in the writings of British and Continental Mineralogists.

In every country there are particular animals and vegetables, which indicate, by their mode of growth and rapid increase, a peculiar adaptation to the soil and climate of that district. Hence we find a remarkable difference in the animals and plants of different countries. Many shell-fish have indeed a very wide range of latitude, through which they may be observed; but we know, that the same molluscous animals which are natives of Britain, are not found, as a whole, as natives of Spain, while the molluscous animals of Africa differ from both. If the same arrangement of the molluscous animals always prevailed in the different stages of their existence, then we may expect to find the fossil shells of one country differing as much from those of another, as the recent kinds are known to do, so that every country will have its *fossil*, as well as its *recent* testacea. Few observations illustrative of this branch of the subject have hitherto been published.

It has often been remarked, that the fossil shells (and the relics of other animals and plants) found in the strata of this country, are very different in their appearance from those shells of the mollusca which at present exist in the country, but that they bear a close resemblance to the existing species of the equatorial regions. This very important observation would lead us to conclude, that the mollusca which lived in this country at the period of the formation of the strata in which they are now enclosed, were influenced by different physical circumstances, from those, by which the forms of the recent kinds are regulated; but it by no means warrants the conclusion, that those shells once lived in the equatorial regions, and that a mighty deluge transported them to their present situation. This last conclusion can never be admitted by those who have witnessed the perfect preservation of the different parts of fossil shells, their valves, spires, protuberances, and delicate spines, still unbroken. Though these species no longer exist, in a living state, in this country (nor on the globe), we must admit the conclusion of Werner (with regard to fossil plants), that they lived and died in the country where their relics are now found.

It would form a very curious subject of inquiry to ascertain the character of those fossil shells which are found in the strata near the equator. If they likewise differ from the recent species of those seas, and if, in appearance, they resemble the productions of arctic regions, we might then speculate, with more success, upon those mighty revolutions which have taken place on the earth's surface, and trace in the mineral kingdom the proofs of those changes which animals and vegetables have experienced. In the meantime, we would recommend the examination of the laws which regulate the physical and geographical distribution of recent shells, as the most suitable preparation for investigating the condition of those extinct races, whose memorials are preserved in strata, differing from one another in structure, position, and composition.

See MOLLUSCA for a classification of shells whose animals are known, and SHELLS for a description of the genera whose animals are unknown.

(Q. Q.)

CONDAMINE (Charles Maria de la), a practical Geographer and cultivator of science in general; son of Charles de la Condamine, a Receiver General of Finances, and Margaret Louisa de Chources; was born the 28th of January 1701.

His early education was by no means neglected; although he complains, in a manuscript memoir which he left respecting the progress of his studies, and the developement of his faculties, that he was made to learn, as boys frequently are, too much by rote, without understanding the complete sense and bearing of the words which he repeated. It is, however, by no means certain, that any great loss of time is ultimately incurred by this practice; for in fact the memory is much strengthened by the constant habit of getting by heart; and it does not appear that the judgment is at all impaired by it. He afterwards pursued his studies under Father Brisson, and in 1717 supported a thesis on the Cartesian philosophy, which the Jesuits were then beginning to introduce into their seminaries, while it was elsewhere giving way to the Newtonian. In 1719, after he had left college, he entered the army, and accompanied his uncle, the Chevalier de Chources, to the siege of Rosas, as a volunteer; and both on this and other occasions, he exhibited sufficient proofs of the contempt of danger, and the spirit of enterprise, which were so much required in those pursuits, which afterwards occupied a considerable portion of his life. Notwithstanding the dissipations in which military men are very commonly involved, he was moderate in the pursuit of pleasure; and he used to consider the distortion, which the small-pox had left in his features, as having afforded him some compensation for the injury done to his vanity, by diminishing the temptations to which his sensibility might otherwise have exposed him.

Having no prospect of speedy advancement in the army, and having suffered considerably in his fortune from a participation in the extravagant speculations of Law, he quitted the service, in hopes of finding a more advantageous employment in science. He distinguished himself as an active member of a society of arts, then recently established at Paris by the Count de Clermont; and, in 1730, he obtained a situation in the Academy of Sciences, as Adjunct of the class of Chemistry, having previously presented to the Academy a Memoir on the mathematical and mechanical properties of the lathe, which obtained him considerable credit. Soon afterwards he embarked in the squadron of Duguay Trouin, and made a voyage in different parts of the Mediterranean; he passed several months at Constantinople, and visited the plain of Troy and many other parts of the Levant; after his return he gave an account of his tour to the Academy; and a servant, who had accompanied him, published also a separate journal of his own.

Chemistry, as it was cultivated at that period, afforded but little scope for the employment of an active mind, and La Condamine, after the publication of one chemical memoir only, was removed from the class of chemists in the academy to that of astronomers. In this capacity, he was the first to propose the measurement of a degree of latitude in the neighbourhood of the equator: and he seems to have felt the importance of the undertaking, not only for the purpose of deciding a great question in science, but also for that of attracting the attention of the public, and establishing the system of gravitation in France by a grand operation, executed, with great labour and at a great distance, by Frenchmen only. His ideas were readily seconded by Maurepas, then prime minister; and he was appointed by the Academy, together with Bouguer and Godin, for carrying the proposal into effect.

In this expedition he was absent from his country for nearly ten years, from 1735 to 1745; and he had to combat with difficulties of every kind: a distant voyage: an uncivilized and sometimes uninhabited country; impracticable roads; want of regular remittances; the necessity of disposing of valuable articles disadvantageously, in order to procure a temporary supply; a malicious prosecution upon the pretence of a contraband traffic, founded only on this circumstance; and the still more violent attacks of a fanatical mob, who murdered the surgeon of the expedition; all these things, to say nothing of the awful appearance of an eruption of Cotopaxi, and the no less formidable operations of the hostile squadron of Lord Anson, required nothing less than the dauntless spirit and energy of character which he possessed, to bear him up against them; and at last the little jealousies, which will often arise among persons of science, employed in the same pursuits, embarrassed and embittered the conclusion of his enterprise. The activity and fluency of La Condamine made the public disposed to imagine, that Bouguer had been only his humble attendant; and Bouguer was too conscious of his own superiority as a mathematician, to bear this injustice with patience: he complained, but the laugh was against him; and he revenged himself by refusing all communication in the statement of the results of the operations: so that each observer gave ultimately a separate account of his own measurements and calculations.

In consequence of all the fatigues and vicissitudes to which La Condamine had been exposed, he became extremely deaf, and partially paralytic after his return; but the powers of his mind appear to have remained unimpaired.

In 1748 he was elected a Foreign Member of the Royal Society of London; and he afterwards exerted himself with great zeal and success in promoting, among his countrymen, the general introduction of the variolous inoculation, which had long been practised in England, and in some other parts of Europe. In 1757 he took a journey to Italy, and spent a considerable time at Rome, partly with a view to the improvement of his health, and to the observation of a variety of facts connected with his scientific pursuits; but principally, perhaps, in order to obtain a dispensation from the Pope for a marriage with his niece, who seems to have had a high respect for his talents, and even a sincere attachment to his person, notwithstanding the disparity of their ages, and the caprices of a temper not a little impatient and irritable. He became, in 1760, one of the forty members of the French Academy, and contributed considerably to an improved edition of

their dictionary. In 1763 he paid a short visit to England, which was rendered less agreeable to him on account of the difficulty that he found in obtaining legal redress for some slight injury which he had received: after his return, the insensibility of his limbs increased, and he was obliged to relinquish all his pursuits of science, retaining only the amusement of making some light attempts in poetry, and occasionally inserting in the periodical works of the day a few tales in verse, besides a poetical translation of a part of Virgil's *Eneid;* although it seems natural to suppose that the exercise of the inventive fancy of a poet would tend to exhaust the debilitated faculties, even still more, than the methodical investigation of mathematical or physical subjects.

1. The first of Mr de la Condamine's publications was a *Memoir on the Conic Sections*, M. Ac. Par. 1731, p. 240. It contains a comparison of the equations of the various parallel sections of a given cone with that of the surface of the cone itself; but it is not remarkably distinguished either for clearness of conception, or for accuracy of expression.

2. *On Metallic Vegetation*, M. Ac. Par. 1731, p. 466. H. P. 31. The experiments described in this paper relate to the precipitation of nitrate of silver, or other metallic solutions, placed upon a flat surface of glass or agate, by means of an iron nail; and the only remarkable circumstance attending them is the extension of the ramifications to parts at a considerable distance from the nail which supplies the iron in the place of the silver deposited; exhibiting a faint resemblance of the astonishing transfers and interchanges which have been more lately discovered in electrochemical experiments.

3. *Observations made in the Levant*, M. Ac. Par. 1732, p. 295. Relating principally to navigation, to geography, and to natural history. The author had agreed to undertake an expedition into the interior of Africa; but his arrangements were interrupted for want of the expected co-operation.

4. *Account of an Instrument for determining a Parallel Circle on the Earth's Surface*, M. Ac. Par. 1733, p. 294. H. P. 53. A telescope fixed perpendicularly on an axis, parallel to that of the earth, and consequently capable of being directed only to objects situated in the parallel circle required; proper allowance being made for the effects of refraction.

5. *Description of a Variation Compass*, M. Ac. Par. 1733, p. 446. A wire is fixed in the axis of the card, and a graduated ring of paper round its circumference, half above and half below, on which the shadow of the wire is to fall at sunset.

6. *Two Memoirs on the Lathe*, M. Ac. Par. 1734, p. 216, 295. A description of the rosette and of other parts of the figure lathe, with a mathematical determination of the epicycloids, conchoids, and other curves, which are traced by their combination. The apparatus is represented among the machines approved by the Academy, Vol. V. p. 83, 89.

7. *A Letter relating to the Variation Compass*, M. Ac. Par. 1734, p. 597. Containing testimonials in its favour, with a mode of observing, by looking directly at the wire and at the setting sun, when his light is too faint to cast a shadow.

8. *On the Determination of small Differences of Longitude*, M. Ac. Par. 1735, p. 1. A discussion of the kinds of signals best adapted for contemporaneous observations at a distance; a subject much more difficult at that time than at present, when the art of pyrotechny has been carried to so high a degree of perfection, especially since the late singular invention of a rocket with a parachute, descending slowly and exhibiting successive explosions.

9. *Measurement of the Length of the Pendulum at St Domingo*, M. Ac. Par. 1735, p. 529. The academicians were detained at St Domingo more than three months, and they took advantage of the delay in order to ascertain the length of the pendulum in that latitude. Mr de la Condamine employed a ball of brass, suspended by a thread of the aloe, and attached to it by means of a piece of sticking plaster; the pendulum making a vibration in about two seconds, he observed in how many vibrations a second was lost or gained. The length, thus determined, was 36 French inches $7\frac{1}{4}$ lines, or 39.0125 English inches; Messrs Godin and Bouguer made it one-twelfth of a line longer, or 39.020, and a calculation from the best modern observations, for the latitude, which was $18^0\ 27'$, gives us 39.029. The thread was fixed by a clip, and it was probably very flexible, since its rigidity must necessarily have tended to increase the curvature of the path of the ball, and to give a measure somewhat too long. See the article Cohesion, of this Supplement.

10. *Account of the Quinquina Tree*, M. Ac. Par. 1738, p. 226. Jussieu, who was the botanist of the expedition, had pointed out to La Condamine a number of circumstances respecting the cinchona, which required investigation; and he was enabled to illustrate them in a satisfactory manner, from having to pass through Loxa in the course of his investigations. It appears that the bark, known under the name of *quina quina*, before the discovery of the *cinchona*, was the cascarilla; and these two articles have sometimes been confounded, though very different in their nature and effects.

11. *Abstract of a Journey through a part of South America*, M. Ac. Par. 1745, p. 391, H. 63. After the completion of the operations at Quito, Mr de la Condamine determined to take the course of the river Maranon for his return towards Cayenne; and in the course of this route, of more than 2000 miles, which he performed partly by land, but principally on a raft, he had an opportunity of making a multitude of interesting observations of various kinds. He found in several places a singular agreement of traditions respecting the former existence of a Republic of women only, in the neighbourhood of the river which has received its most usual denomination from them. He observed the effect of the tides at Pauxis, a point 600 miles from the mouth of the river, but not much elevated above it; and he was informed that there were always a number of alternations of high and low water at the same time, between this point and the mouth of the river; in some places, where the water was shallow, he encountered the tide rising in the form of a bore, called by the French a *barre* or *mascaret*, and by the inhabitants there a *pororoca*, occupying but one or two minutes in its ascent, and frequently producing

accidents to boats unprepared for its reception. After his arrival at Para he measured the length of the pendulum there, and found that the force of gravitation was about $\frac{1}{1000}$ greater than at the summit of Pichincha. He next proceeded to Cayenne, and was obliged, on account of the war, to return to Europe by a Dutch ship, which sailed from Surinam.

12. *Abstract of the Geographical Operations performed in South America*, M. Ac. Par. 1746, p. 618. The length of a degree at the equator appears, from these calculations, to be 56,750 toises; Bouguer, who employs the same determination of the arc, but a different series of trigonometrical observations, makes it 56,753; and Godin, on the other hand, somewhat less than La Condamine. This is more than 300 toises less than the degree measured in France, and almost 700 less than the degree in Lapland; and it gives for the earth's ellipticity, by comparison with the former, $\frac{1}{303}$, and with the latter $\frac{1}{213}$. The terminations of the base were marked by pyramids, and the length of the toise was identified by a bar of metal, let into a tablet of marble, with an appropriate inscription.

13. *Mesure des Trois premiers Degres du Meridien*. 4. Par. 1751, with a complete journal of the operations.

14. *A Proposal for an Invariable Standard of Measures*, M. Ac. Par. 1747, p. 489. H. p. 82. Many arguments are advanced in favour of the uniformity of measures in all countries, and the length of the pendulum at the equator is considered as the most proper for universal adoption, as the fundamental unit.

15. *Account of an Elastic Resin*, M. Ac. Par. 1751, p. 319. H. p. 17. A description of several trees, affording the cahuchu, or caoutchouc; especially of the Hheve, or syringe trees, chiefly from Mr Fresneau's communications.

16. *A History of the Variolous Inoculation*. M. Ac. Par. 1754, p. 615. A candid, clear, and judicious statement of the advantages of the inoculated above the natural small-pox, in a popular and sometimes even playful style, calculated to meet the prejudices of the day, and the various superstitious and interested motives which retarded the practice in France, while it had become universally prevalent in England; although, in more recent times, the public spirit in this country appears to be somewhat less favourably disposed to the admission of beneficial innovations; for scarcely in any part of the world has vaccination become less universal than it is at this time in Great Britain.

17. *Abstract of a Journey in Italy*, M. Ac. Par. 1757, p. 336. H. p. 6. From an examination of several ancient standards, and from a comparison of the remains of buildings supposed to have occupied a certain round number of feet, Mr de la Condamine concludes that the old Roman foot was equal to 130.9 French lines; that is, to 969 thousandth of an English foot. Mr Folkes had before made it 966; but Mr Raper has shown, in the *Philosophical Transactions* for 1760, by a very careful comparison of a multitude of documents, that before the reign of Titus, it somewhat exceeded 970, and under Severus and Diocletian, it was less than 965; the original standard in the temple of Juno Moneta having probably been destroyed by fire. Mr de la Condamine also viewed the races on the Corso, with an eye equally mathematical, and observed that the Barbary horses ran at the rate of about 40 English feet in a second; but his correspondents in England furnished him with unexceptionable evidence, that the horse *Childers* ran the four mile course at Newmarket at the rate of very nearly 50 English feet in a second, while no other horse exceeded 48; and he observes that, in this instance, truth far outruns probability; a remark which has been somewhat misrepresented in this country, and converted, by the lovers of the amusements of the turf, into a laugh against the lovers of the amusements of science; the story being told as if the French mathematicians had demonstrated the absolute maximum of a horse's utmost possible speed; and a bet having been made on the occasion, an English horse had been found that actually exceeded the maximum. Our author also notices the awkward effect of the Roman mode of beginning the day at sun-set, which renders it necessary to make continual alterations in the clocks, directions being given in the Almanacks for putting them forwards or backwards a quarter of an hour at a time; and the precise time of noon happening in summer at 16 o'clock, and in winter not till 19. He observes that a single signal, properly placed on the Apennines, would be visible at once near Trieste and near Monaco, giving a difference of longitude of not less than five degrees.

18, 19. *On Inoculation*, M. Ac. Par. 1758, p. 439. 1765, p. 505.

20, 21. Mr de la Condamine published also a series of *Lettres sur les Dictionnaires*, and another of *Lettres sur l'Education*.

In 1768 his name is mentioned as having excited the attention of the members of the Academy by a relation of Spallanzani's experiments on the reproduction of the heads of snails, which several of them repeated with success. In fact, there was scarcely any one of the sciences to which he did not occasionally render some service, although he wanted patience and perseverance to make any very important discoveries or improvements, by his individual exertions only. But his knowledge was universal; he understood and wrote all languages; he corresponded with men of celebrity in all countries; he published upon all subjects; he contributed to all the literary and scientific journals of the day; he answered all criticisms, and he accepted all compliments, even from persons that he despised; for he delighted in the parade of a preeminent reputation. His style was simple and natural; a little negligent, but still elegant and lively; his manner was animated and somewhat singular; his temper was warm and restless; he sighed for repose, and was incapable of enjoying it; thinking nothing that occurred indifferent to him, and allowing none about him to be idle. He obtained the rank of chevalier in several orders, and was a member of several foreign academies; he had also the appointment of honorary secretary to the Duke of Orleans. At the age of 68, he addressed to his wife an account of his education, and of the earlier pro-

gress of his mental faculties, as a practical illustration of his opinions respecting the cultivation of the mind: the memoir was not published; but it is perhaps unfortunate for mankind that men of celebrity seldom find a sufficient motive for communicating candidly to the world the results of such a self-examination. A few years before his death, he printed a memorial in behalf of Mr Godin, who had been reduced to indigent circumstances; and he had the pleasure of obtaining for him the assistance which he required. He suffered occasionally from a hernia, and having read of the marvellous cures which some empiric professed to have performed by the application of a caustic, he determined to make the experiment on himself, without the knowledge of his family, and without much hope of success; but he fell a victim to the courage, or the curiosity, that prompted him to submit to the operation. In the course of the six weeks that he survived, he was still employed in writing or dictating a memoir containing answers to some questions respecting the manners of the Americans. He died on the 4th February 1774, leaving many of his books and instruments by will to the Academy of Sciences. (*Hist. Acad. Par.* 1774. p. 85.) (R. T.)

CONDILLAC (ETIENNE BONNOT DE), Abbé de Mureaux, well known as an eminent writer on Metaphysics and Education, was born at Grenoble in 1715. He was brother to the Abbé de Mably; and, like him, arrived at high celebrity, though in a different line of pursuit. He seems to have been actuated by the purest motives of utility to his species, in directing his exertions to the elucidation of those subjects in Metaphysical Science, the imperfect state of which had involved the studies, as well as the public pursuits, of the thinking world, in perplexity, and had retarded the attainment of that degree of sound knowledge and of happiness for which the faculties of man entitled him to hope. The field of Metaphysical research had been for some time laid open by the destruction of the imperious authority of Aristotle and the Schools; a variety of contending doctrines, which had made their appearance, created in active minds a spirit of independence; and no admiration of the genius of another prevented the suggestions of the philosophic critic from mingling themselves with the illustrations of the enlightened pupil. Locke had led the way to a mode of investigation now rising into favour, and promising to impart a luminous simplicity to the science of mind; and philosophers emulated one another in their efforts to correct or to extend the doctrines of this author, or to found upon them others distinguished by new improvements. Condillac was one of the first who introduced this style of Metaphysical inquiry into French literature. His earliest work was his *Essai sur l'origine des connoisances humaines*, which appeared in 1746. This work contains those favourite opinions which are exhibited with more correct taste in his subsequent productions. It is not, however, superseded by the latter, as it contains a variety of interesting illustrations peculiar to itself. And although here we find his errors particularly prominent, that circumstance seems rather to proceed from the absence of art and plausibility, than from the subsequent adoption of views more radically correct. From the outline which he first formed of philosophic methods, he seems never to have departed. The object of the first part of this Essay is to confirm and extend the doctrine of Locke, that all ideas originate in the senses, and consist of sensations variously modified. Readers who conceive that Locke's doctrine, when followed to its consequences, tends to lower the estimation in which the human mind ought to be held, will probably attach the same blame to Condillac. His curious saving clause will not vindicate his opinions among the Philosophers of this country, however convenient it might be found among the adherents of the Romish Church, that the dependence of the soul on the senses is one of the effects of the fall of man, and a proof of his present state of degradation. Readers who are not ambitious of possessing a fixed theory in a department of Metaphysics so abstruse, will be pleased with those traits of acuteness in the observation of mental phenomena, which abound in this Essay, and which are often expressed with great felicity, even while the slight distortions communicated to some of his representations of facts by the tendencies of his theories, obtrude themselves on our notice. The doctrine now mentioned is followed up by two other leading positions, "that the association of ideas is the foundation of the most important mental operations," and "that language is absolutely necessary to the developement of the human faculties." Ideas, he asserts, cannot be associated with one another, except by being associated with words or other signs which become the materials of a language. On this doctrine he establishes a definition of memory, which is altogether unique, that it consists in the recalling of words, or circumstances relating to a perception; the recalling of the perception itself belongs to imagination, while it is reminiscence that makes us recognize it as one which we have formerly entertained. He denies all memory to animals, because they have no language. Thus a futile fallacy led him to form a verbal distinction, founded on no difference in the nature of things. A person destitute of language, and wishing to have it in his power, on future occasions, to recall a particular idea, might certainly find means adapted to his purpose, by associating it with different objects. These objects would serve the same purpose as the signs of which our languages consist. Some such associations are essential to memory. The slightest attention will show us, that words or signs serve no other purpose than is done by all kinds of ideas, in assisting the mind to make use of one another. What this author calls a sign, is merely another idea intentionally associated with that which we principally wish to recollect. We may give the latter numerous associations, that it may have many chances of being recalled. We associate it either with the most important or with the readiest of our perceptions, that it may be recalled more perfectly, or with greater certainty. The only circumstances that render some perceptions better adapted to this end than others, are their importance, their familiarity, and their analogy with those which have been previously used. We generally choose our instruments of private recollection

Condillac. from the materials of language, because these materials are already employed for communication. They are rendered convenient by their variety, and by the classifications and analogies which were followed in the first formation of them, as necessary for rendering them the media of communication, and which, by connecting them powerfully together, give them a high adaptation for extensive arrangements. Language, in that state of improvement in which it exists in a cultivated age, extends intellectual operations; but it neither adds any radically distinct faculty, nor gives origin to any new genus of mental exercise. Condillac says, that "a man without language could not recall his ideas, except when placed in the same circumstances in which they had been formerly presented." The obvious answer to this is, that language, in so far as it serves this purpose, consists in the multiplication of the assisting circumstances in which a man is placed when a perception is formed. Many ingenious illustrations are subjoined, which are deserving of attention; but, when well considered, they will lead to conclusions differing from those which the author endeavours to establish. In viewing the mind in its active state, he justly observes, that objects attract its attention, only as they are connected with our temperament, our passions, our condition, and our wants; and this principle is afterwards beautifully applied to the illustration of the earliest acquisitions of knowledge, and of the difference of character between them and many that succeed at a later period. But no person would affirm, that our wants are the signs of our perceptions, though various perceptions are powerfully recalled by their means.

The opinions of the author certainly led him to ascribe too much to language. It is to the want of signs that he traces the whole disadvantages of the deaf, whereas we know that they are entirely owing to the deficiencies of their mental intercourse with others, that is, to their privation, not of the private, but of the social use of language. We find that the great improvements now made in the art of communicating with the deaf have made these disadvantages to disappear. The young man of Chartres, who was born deaf, but acquired the faculty of hearing when of adult age, and was therefore able to describe the state of his understanding during his former deafness, declared, that when he made the sign of the cross, and joined in the other ceremonies of the Roman Catholic religion, he had never attached to them any meaning, or supposed that any thing was represented by them. Thus, for want of language, he is represented as destitute of ideas. In this instance, however, we only perceive the facility with which men imitate one another's acts and professions, without exercising independent thought. The difference between this deaf man and most other persons was, that he took the propriety of the ceremonies for granted, being entirely led by example, while those who had heard their meaning explained, acquiesced with reverence and complacency in certain verbal positions connected with them, without ever inquiring into their meaning or their merits. Another illustration is taken from a man, who, though he enjoyed the faculty of hearing, had lived apart from all association with his species in the forest of Lithuania. But it is easy to show, that the great mental deficiencies of that individual arose from the want of society, and not simply from the want of a language to supply his private meditations with signs. Condillac.

It is in the art of calculation that the utility of signs is most conspicuous in forwarding the progress of intellectual operation, and it is there that we find a language presented to the eye, which is adapted in a most perfect degree to the purposes of the mind. Hence the use of signs for expressing our ideas of number, is a favourite topic with Condillac and the other adherents of the doctrines of the Nominalists. The number 99 could not be distinguished from a hundred, except by language. Ninety-nine objects placed together, would not convey a different perception from a number varying from it by one less or one more. It is an error, however, to imagine, that the words One Hundred, or the cyphers (100), by which the number is represented, give us a perfect idea of any number. They only represent one relation of it to a certain mode of accumulation, the decimal series. Independently of all language, general features may be perceived to characterize objects too complicated to be comprehended by any human mind.

Condillac, seduced by his favourite theories, condemns one of the most profound and useful of the practical observations of Locke, that the best way of arriving at correct knowledge is to consider ideas by themselves, independently of their signs. This exercise our author pronounces to be utterly impracticable; and all that he attempts to recommend in its stead, is the precaution of employing only such words as are well understood. How can words be understood, unless the ideas which they represent are considered as detached from all association with them, and thus exempted from the embarrassing influence of fallacious analogies?

Regarding language as a necessary instrument of mental operations, he makes some observations on the parts of speech, and the manner in which they are connected in sentences. He describes with ingenuity the steps by which words pass from expressing sensible qualities to become the names of mental faculties. Here we perceive a glimmering of some truths which have been since luminously displayed in the *Philosophical Essays* of Mr Dugald Stewart. He introduces, at the same time, some speculations on the origin of abstract terms, which are not entitled to equal approbation. He takes occasion, however, to make one remark which is both beautiful and just, that men have too often imagined that words perfectly explain the essence and nature of things, whereas they express in reality nothing more than some imperfect analogies. This position, followed to its consequences, would suggest a correction of a great part of the author's errors.

In describing the pronoun, he gives way to a species of metaphysical mysticism, by which he is grievously misled. He conceives that this class of words must be of late formation, because some difficulty must have occurred in substituting another word for the proper name of an object. He did not here consider, that nothing of the essence of an object, no-

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thing but qualities, circumstances, or accidents is expressed by the proper name, more than by the pronoun. The same man may be "John," "father," "brother," "master," "subject," "I," "thou," or "he," according to the occasions on which the mention of him is introduced. All the designations applied to him are equally proper and easily made.

Yet this work is well worthy of an attentive perusal. We find in it a brilliancy of expression which renders it more amusing than metaphysical dissertations often are; although it must be confessed that there is in some instances a false simplicity, arising from an attempt to represent metaphysical science as easier than it really is. In his subsequent works he acknowledges that he had fallen into some errors from the precipitate views which he took of the mental powers; but he specifies no particulars; and a reader who does not acquiesce in all his improved views will not easily see the exact corrections which the author made on those contained in his *Essai*.

In 1749 he published his *Traité des Systemes*, the object of which was to show the futility of the doctrines derived from those hypothetical systems which were the offspring of an erroneous mode of procedure in the pursuit of knowledge; such as those which set out with general or abstract maxims, and pretend to establish on them a body of profound science. Another kind consists of arbitrary suppositions, laid down as principles for the explanation of things which cannot be otherwise accounted for. These are a convenient resource for ignorance; they are formed with so much pleasure and so little trouble, that a man in bed may, by their aid, create and govern the universe. He illustrates the conspicuous influence which this mode of systematizing had on opinions in metaphysics. He takes a view of the system of innate ideas as maintained by Descartes; that of Malebranche, who reduced all knowledge and all mental activity to operations which had the divine essence for their objects; that of Leibnitz, who explained the laws both of matter and of mind by general functions pertaining to simple and indivisible beings, which he called *monades;* and that of Spinosa, who reduced all nature and all existence to one simple substance, of which the various phenomena, material and mental, are only modifications. The last of these systems had created some commotion in the philosophical and religious world, as adverse to a belief in moral distinctions. Condillac treats the argument with a dignified delicacy, as having received a wrong direction in the writings of that author, in consequence of the erroneous methods of investigation which he employed. His words are, "Does Bayle believe that he has refuted Spinosa, by exposing the consequences which he himself draws from the system of that philosopher? If these are not really its consequences, he does not attack Spinosa. If they are, Spinosa will reply, that they are not at all absurd, and only appear so to persons who are unable to ascend to the principles of things. Destroy, he will say, my principles, if you would overthrow my system; or if you let my principles alone, assent to the propositions which are their necessary consequences." "My object," says Condillac, "has been to show that Spinosa had no idea of the positions which he advanced, that his definitions are vague, his axioms inaccurate, and his propositions entirely the work of imagination, and include nothing that can lead to the knowledge of things. Having done this, I proceed no farther. To attack the phantoms which arise from his principles would be as preposterous as the feats of the knights-errant, who combated the spectres of the sorcerers. The wisest plan is to destroy the enchantment." Having shown the radical fallacy of the principles adopted by the preceding writers, he points out the cases in which hypotheses assist human knowledge. The first is, when we can exhaust all the hypotheses that can be formed on any subject, and possess a rule for distinguishing that which is admissible. Of this we have examples in the pure mathematics. A second kind of hypothesis includes those which are employed in astronomy, provided they are limited to the object of accounting for the revolutions of the heavenly bodies. A third occasion on which they ought not to be rejected is, when they facilitate observation, by giving greater palpability to truths attested by experience. He mentions the importance of general systems formed by a process of induction. He points out the necessity of general systems in politics, founded on the character and condition of the different classes of men who constitute the body politic; and concludes with a view of the advantage derived from system in the arts. He gives some useful practical observations on the application of mathematical and metaphysical analysis. This treatise abounds in excellent remarks on human character, as displayed both in intellectual pursuits and in the business of life. His comparison of Locke and Malebranche is a masterpiece of description.

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Next in order, his *Traitè des Sensations* made its appearance in 1754,—a work which displays a truly philosophical spirit, uniting boldness with circumspection. The mode in which he investigates the origin of ideas of sense, and the progress of intellectual operation, had the merit of some originality, and afforded an undoubted advantage to the prosecution of the most interesting inquiries. He considers the senses in a separate state, by forming the supposition of a being created without sensations. He supposes this being in the first instance to be endowed with the sense of smell, and describes the mental character which would thus be formed. He gives a similar account of the other senses, and examines successively the effects of their combinations till he arrives at the description of a complete human being.

His uniform aim is to show *that all ideas and all mental phenomena consist of sensations transformed.* Those who reject that doctrine will still acknowledge the beauty and ingenuity of his train of description. The conclusion itself is refuted by the slightest reflection on the very scope of the author. He evidently supposes the man who becomes thus complete by receiving his different external senses in succession, to have been previously in possession of dormant intellectual faculties. For his descriptions, while they apply to man, will not apply to many other animated beings whose senses are equally perfect, because the use which they are able

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to make of the impressions received is either incomparably more limited or different in kind. If the results of intellectual operation are nothing else than sensations transformed, the transformation is certainly more important than the original materials, and the transforming power cannot be lightly esteemed by any one who values extended knowledge. The favourite theme of the author, however, detracts but little from the pleasure which this ingenious work imparts. Some would pronounce the discussions which it contains to be not strictly analytical. Analysis should begin with man as he exists in a complicated state, with all his senses as well as his faculties entire, and proceed to separate his constituent powers by successive subdivisions, till, in its progress downwards, it arrives at the description of each sense and each species of intellectual operation in a separate and simple state. The description of a man endowed in that kind of succession which Condillac describes, is a purely hypothetical process, more allied to arbitrary synthesis than to analysis. By analysis, however, the author means, in a general way, the task of surveying, in succession, the parts of which compound objects consist, and examining separately the relations by which they are connected, without any reference to the order of procedure. Decomposition, and recomposition, he, in a subsequent work, represents as alike belonging to analysis; and though from etymology the Greek word *Synthesis* is the same with that of the Latin word *Composition*, he limits the former term to that mode of composition which he condemns, that which begins with general or abstract doctrines, and which regards these as the ground of systems pretending to explain the existing world. Although his order of description of the senses is so far hypothetical as to have nothing corresponding to it in the natural history of man, he regarded it as sufficiently capable of being substantiated by close comparison with every man's experience, and thus distinguished from the offspring of an arbitrary synthesis.

These works having procured for the author a distinguished character in the philosophical world, he was appointed preceptor to the infant Duke of Parma, grandson of Louis XV.; and, in applying himself to the discharge of the duties of that office, he brought into exercise the same talents which had shone so conspicuously in his writings. He composed a course of studies (*Cours d'Etudes*) in 13 volumes, including *Grammaire*, *l'Art d'Ecrire*, *l'Art de Raisonner*, *l'Art de Penser*, occupying the first four volumes, succeeded by nine volumes *On Ancient and Modern History*. His *Grammaire* exhibits, in his own able manner, doctrines in universal grammar nearly allied to those which generally prevailed, and which we find in the *Grammaire Generale et Raisonnée*, of the Port Royal. The author's favourite principle, that every language is an analytical method, runs through the body of his work, and probably leads him to pay too great respect to the technical differences of the parts of speech, as indicating thoughts of different classes. *L'Art d'Ecrire* is a most agreeable and enlightened system of general criticism, and adds to this the merit of exhibiting an interesting view of French literature, in the examples of good and of faulty writing, by which the precepts contained in it are illustrated. The whole rules relative to style are referred to one principle, that a writer ought to conform his diction and his imagery to the most fundamental associations of ideas. His rules, thus deduced, do not exhibit any such difference from those of other authors as to form in his readers a style marked by any singularities. On the contrary, we find him exempting literature from the shackles of some rules, the close observance of which secures an apparent accuracy at the expence of a natural ease, and showing his susceptibility to the influence of a pure taste by bestowing approbation on passages which a critic of a more formal cast would have thought himself called upon to censure. His *Art de Raisonner* is a work of singular excellence and utility. It is a luminous exemplification of the rules of reasoning, in the steps of that mental progress by which physical philosophers have unfolded the laws of motion, the principles of mechanics, and the theory of the heavenly bodies. He discriminates, with just and beautiful effect, the different kinds of evidence on which the various doctrines of those branches of natural philosophy rest. This Treatise is well worthy of being known in our language; as it exhibits an uncommonly pleasing road to an elegant department of physical knowledge, and furnishes a model for the prosecution of other studies. His *Art de Penser*, notwithstanding all the ability which it displays, will probably be found the least interesting part of the *Cours d'Etudes*, as it chiefly consists in an explanation and recommendation of the author's peculiar notions on the nature of mind. His *Ancient and Modern History* forms a body of morality and legislation. His details are not inspirited with the ardent eloquence of a popular historian who excites a deep interest in individual characters or insulated events. He does not exhibit paintings to the imagination, but contents himself with furnishing leading principles to the understanding. His style, though pure, is without ornament and without fire, and hence his history has been much less read than his other works.

In 1768 he was admitted into the Academy of Sciences, on the death of the Abbé d'Olivet, but he never afterward appeared at any of the meetings of that body.

His attention being habitually directed to those subjects in which intellectual exertion was most wanted, for the advancement of objects of general utility, he published, in 1776, the results of his studies on Political Economy, in a work entitled *Le Commerce et le Gouvernement, considerés relativement l'un à l'autre.* This work became an object of attack to the Economists; and the author, no doubt, like most others who have written on that subject, committed some mistakes. Yet he essentially improved the discussions connected with it, and he exhibits a model of luminous arrangement in his mode of delivering his opinions.

The extended fame of Condillac procured for him a most honourable testimony of esteem from the Polish nation. The council of public instruction of

Condillac.

that nation requested him, through the medium of Count Ignatius Potocki, to draw up an elementary treatise on logic, for the use of their palatinal schools. This gave birth to his *Logique*, which was published in 1780, a few months before his death. The object of this work is to give a condensed account of the principles of *analysis*, taken in the acceptation already mentioned. This process, he observes, is taught by nature, and is always conducted with accuracy when man is in quest of the means of supplying the urgent necessities of his being. It is when curiosity forms to him a separate order of objects for his gratification, that he becomes precipitate in grasping at conclusions, and embraces them with readiness, though not the produce of that rigorous correctness of method which necessity imposes on his earlier pursuits. In giving an account of the origin of ideas and the mental faculties, he exemplifies his views of analysis, and, at the same time, prepares the way for farther applications of the mental powers of his pupils. He adheres to his doctrine of the supreme and exclusive influence of language in conducting all intellectual pursuits. Generalization and classification are, with him, nothing more than the contrivance of generic names. The art of reasoning is made to consist in the formation of an appropriate language for the different sciences. He considers the justness of our reasonings as depending on the degree of perfection of the languages which we possess. The superior certainty of mathematical compared with other knowledge is ascribed by him to the superior accuracy of mathematical language. Hence his favourite illustrations of the progress of the mind are taken from arithmetic and algebra. This principle is certainly carried by him to great excess in the framing of his general positions; yet we find him on other occasions recommending to his readers to cultivate the unbiassed study of nature, and to choose their words rather from the correctness of their application to objects, as they have fallen under actual observation, than from having their meaning fixed by the unsatisfactory formality of verbal definitions. He lays down some highly useful rules for the prosecution of knowledge. His errors chiefly arise from a strained effort to give to his subject a degree of simplicity not adapted to its nature. Hence some of his maxims are more quaint than just; but, compared with the complicated systems of logic previously in use; that of our author formed an improvement which merited the grateful reception that was given to it; and, even at the present day, if we pardon the paradoxical generalities by which it is disfigured, we may profitably trace, in company with the author, the steps by which many intellectual attainments are made, and the means by which the process admits of being facilitated.

The last work of Condillac, his posthumous treatise, entitled *La Langue des Calculs*, formed an important acquisition to science, which has not, in this country, been duly appreciated. In some subordinate points it is not unexceptionable; for example, he here, as in some of his former works, particularly his *Art de Raisonner*, perpetually repeats the assertion as of the greatest importance, that just reasoning consists in tracing identical propositions, and in passing from identity to identity. Aware of the objection to which this assertion was exposed, that identical propositions can amount to nothing more than futile and stagnant truisms, he imagines that this objection is answered, by stating that, in the different steps of a process of calculation, there is *an identity of ideas*, but *a difference in words*, which is certainly a gross paralogism. In one or two passages he states, with greater truth, though apparently by accident, that a process of calculation consists in considering the same objects in different points of view, a proposition which ought to have had that conspicuous place in his treatise which he gives to his doctrine of perfect identity. If this single alteration is made in the mind of the reader, the *Langue des Calculs* will be perused with the highest profit. An English translation of it would form an important accession to the means of an enlightened education in this country, as leading, by pleasant steps, to the highest scientific attainments.

Condillac || Confederation of the Rhine.

Condillac is to be considered as in the soundest sense of the word an amiable man. If he had an apparent reserve, and in some respects a want of fervour, these apparent defects were more than compensated by the steadiness of his conduct. In early life he was intimate with J. J. Rousseau, Diderot, and Duclos. But he indulged no hazardous speculations on the general interests of mankind, and cherished no modes of thinking which tended to divide or distract the age. He was sincerely public-spirited; and his conciliating sentiments will, perhaps, among those who most accurately weigh them, be respected as morally sublime. As a well-wisher to the fortunes of his species, he acted on a principle which he considers as having uniformly operated in the production of former improvements. He dwells on the value of the attainments already made, as an exercise fitted to create a spontaneous disposition to extend them, divested of the spirit of party, and exempt from rashness. Hence his works were not only much read by individuals, but were employed in many of the continental seminaries of education, and, without exciting discontent or apprehension (except among the inflexible scholastics of Spain), proved successful in illuminating the age in which they appeared.—He died in August 1780, on his estate near Bangenci, where he had cultivated a life of retirement, though not more allied to solitude than as it was exempt from the scenes of public bustle and prevalent ambition. (R. R.)

CONFEDERATION OF THE RHINE, the name of a well-known league entered into by several German princes, in 1805, whereby they separated themselves from the empire, and formed a new political association, under the protection of France. This league was an immediate consequence of the reverses of Austria in the campaign of 1805, and was the first great and avowed measure of Buonaparte, to assume the control of the Germanic empire. After remaining in force somewhat more than seven years, i fell, along with its prime mover; but is still deserving of historical notice for its effects, both in giving, for a time, a co-operating power to France, and in

serving as an introduction to subsequent changes in the organization of the Germanic body.

The treaty in question was signed at Paris on 12th July 1806, and ratified at Munich on the 25th of the same month. It consisted of forty articles, and was subscribed by the following powers:

	Contingents.
The Emperor of France, who engaged to furnish a contingent of	200,000 men.
The King of Bavaria -	30,000
The King of Wirtemberg -	12,000
The Prince Primate - -	
The Grand Duke of Baden -	8000
The Grand Duke of Berg -	5000
The Grand Duke of Hesse-Darmstadt	4000
The Duke of Nassau	
The Duke of Aremberg	
The Prince of Nassau-Weilburg	
The Prince of Hohenzollern Hechingen - - -	
The Prince of Hohenzollern Siegmaringen - -	4000 collectively.
The Prince of Lichtenstein	
The Prince of Salm-Salm	
The Prince of Salm-Kyrburg	
The Prince of Isenburg-Birstein	
The Prince of Leyen -	

Most of the subscribing princes assumed, on this occasion, titles different from those which they had borne when members of the empire. It was stipulated, that they should renounce most of the laws, and all the peculiar titles of the empire; that their common interests should be discussed in a Diet to be assembled at Frankfort on the Maine, and to be divided into the colleges of kings and princes, with the Prince Primate as president of the former, and the Duke of Nassau of the latter; that the members of the Confederation should be unconnected with any power except France, between which and the Confederation an intimate compact was formed, and the Emperor of which was declared hereditary protector of the alliance, with the right of nominating the future Prince Primates. It was farther stipulated, that the confederated princes should exercise the rights of sovereignty over the territories newly incorporated, by this act, with their dominions, leaving private property, however, undisturbed; and that, in the event of any neighbouring power making preparations for war, the contracting parties should arm to the extent of the above-mentioned contingents. Finally, it was provided, that other German princes and states should be allowed to accede to the Confederation, and the league was, accordingly, strengthened by the Grand Duke of Würtzburg (on 3d October 1806), with a contingent of 2000 men; by the King of Saxony (on 11th December 1806), with 20,000 men; by the King of Westphalia (in 1807), with 25,000 men; and in the course of that and the following year, by the Saxon princes, the Dukes of Mecklenburg, and, in short, by all the lesser princes of the west and north of Germany.

Immediately after the communication of the treaty of Confederation to the German Diet, in August 1806, the Emperor Francis made a formal abdication of the title of Emperor of Germany; the ancient constitution of which, long in a state of decline, now became completely dissolved. Buonaparte had soon occasion to put his new auxiliaries to the test,—the war with Prussia breaking out in the course of a couple of months after the formation of the alliance. The victory of Jena, and its unparaleled results, rivetted the yoke around the neck of his new vassals, and supplied him with recruits to go through the short but sanguinary campaign of 1807, in Poland. Unfortunately, the Confederation afforded him a numerous and efficient body of auxiliaries, at a very interesting period, we mean in April 1809, when Austria, encouraged by the resistance of Spain, ventured, alone and unassisted, to take the field in the assertion of her independence. The battle of Wagram put an end to her hopes, and rendered Buonaparte the uncontrolled arbiter of Germany; a station which, in all probability, he would have continued to hold for life, had he not wasted, in the deserts of Russia, the finest army that Europe ever saw. This loss was most acutely felt by the states of the Confederation, particularly by Bavaria, its first and principal member.

It was in the beginning of December (1812), that the great mortality took place among the Bavarians, after they were brought up from Wilna, in the vain hope of their affording protection to the wreck of the French, flying across the Berezina. The general melancholy occasioned by the death of so many of their brave countrymen, and a conviction of the insatiable ambition of Buonaparte, raised among the states of the Confederation a spirit of national independence, and paved the way to that alliance which it was soon in the power of Austria and Prussia to offer to their German neighbours. Hence the easy entry of the allies into Saxony, in April 1813, and the memorable defection of the Saxons in the battle of Leipzig, on 18th October; hence also, the conclusion of a treaty between Austria and Bavaria in the last mentioned month; the eager march of the Bavarians to Hanau to intercept the retreating French; and the obstinate, though unavailing, conflict which took place in the neighbourhood of that city.

The Confederation of the Rhine, already virtually dissolved, became finally annulled in 1814, and was replaced at the Vienna Congress by an association on a larger scale, under the name of the Germanic Confederation. Of this new and comprehensive body, a more particular account will be found under the head of Germany. (D. D.)

CONGELATION. See Cold.

CONGO. In the Article Africa, we made some remarks on the hypothesis as to the junction of the Niger with the Congo; and in the hope of farther information, we shall defer any farther account of it, till we reach the word Zaire, by which name this river is also known.

COOLING. See Cold.

COPPER (the uses of). Metallic copper is used for culinary vessels in many parts of Europe,

Copper.

and, for this purpose, the inner surface of the vessel should be tinned. Large vessels for brewing, dyeing, and the like processes, are made of copper. The making of these vessels constitutes the ordinary business of the coppersmith.

Copper, rolled into sheets, is employed for covering the wooden work of the roofs of churches and large edifices in Germany, Sweden, and other countries. It is a costly covering, and does not possess any notable advantage over lead.

A modern, and now a very extensive, use of sheet-copper is, for the sheathing of ships. That part of the hull of the ship that is in the water is covered with sheet-copper; this covering preserves the wood from the attacks of the worm, and also gives the ship the property of passing more rapidly through the water, as the copper bottom remains always smooth, and does not become foul; for sea-weed and shells will not take root and attach themselves to copper as they do to the bare planks.

Copper bolts are used for fastening the planks and timbers of ships. This is a modern improvement in ship-building. A copper fastened ship or boat is preferable to one with iron fastenings, because the copper bolts remain unaltered by rust, and outlast the wood which they hold together.

Copper plates are used for etching and engraving. Laminated copper is cut into rectangular pieces of the sizes required for different engravings, and the pieces are hammered, scraped smooth, and polished by coppersmiths, who make the preparation of these plates their principal business. The copperplate engraver cuts his design or drawing in furrows on the plate, fills these furrows with ink, and paper being pressed against the plate, the ink is transferred to the paper, and a copy of the drawing is thus got on paper. Copper is the most convenient metal for this sort of engraving; silver has the requisite physical qualities, but it is too scarce and costly; pewter, being soft, is more easily worn by impression than copper; it serves, however, in less delicate work, and is generally used for engraving music.

For the frames of delicate dipping needles and magnetic compasses copper is employed, as it was found that the brass, generally used in philosophical instruments, sometimes contained iron which might affect the magnetic needle.

Copper is drawn into wire, used for the communication with the bells in houses, and for other purposes.

Small pipes for conveying the pit-coal gas from the level of the street to the aperture by which the gas issues, are made of copper or of brass. These pipes are fitted on an iron cylindrical mandril, and a cylindrical ring is drawn over the outside; in this way copper and brass tubes are drawn out. The brass tubes for telescopes are drawn out in the same manner.

Copper coins have been used as a medium of exchange, for objects of small value, by most nations, ancient as well as modern. Greek and Roman copper coins abound in the cabinets of collectors.

The mixture, consisting of a large proportion of copper and a small proportion of silver, called billon in France, is used for coins of small value in that country, Germany, and other parts of Europe. In Britain this alloy is not now used, and the coins are made either of standard gold, of standard silver, or of copper. The use of billon is blameable, as it renders the value of the coins uncertain.

Copper.

Copper may be plated, that is, its surface may be covered with a layer of silver, by rubbing the surface with a mixture of nitrate of silver, muriate of soda, and acidulous tartrate of potass (cream of tartar). But the method practised at Birmingham is the most permanent and effectual; a plate of copper, with a plate of silver applied to it, and borax placed in the interstice, is heated to a particular degree, which requires the skill of the workman to know; it is a degree of heat near that at which copper and silver melt. The two metals thus heated, and in contact, are taken out of the furnace and passed through rollers. There is a fusion and combination of the adjacent surfaces, and their adhesion is perfected by the pressure of the rollers. Copper thus plated is manufactured at Birmingham into candlesticks, teapots, buttons, buckles, and a variety of other articles.

Standard silver coins contain a small proportion of copper, which is useful to give them hardness; this proportion is regulated by each government in Europe; the proportion varies a little in different countries. The combination of gold and copper in various proportions is used for making rings and other trinkets.

Copper is gilded by applying on its surface an amalgam of gold with mercury. Bronze ornaments are gilded in the same way.

Copper united with tin forms bronze. This combination is hard and brittle if the proportion of tin is great; but when the proportion of tin is small the bronze is soft, and possesses tenacity so as not to be easily broken. Ancient nations employed hard bronze, containing much tin, in making sword blades, spear heads, hatchets, and cutting instruments. Bronze cramps are found in ancient buildings in Egypt. Statues and bas-reliefs, various culinary vessels, and different kinds of instruments of soft bronze, are seen in the collections of antiquities. In modern times soft bronze is used for casting cannon and statues.

Copper melted with a large proportion of tin constitutes bell-metal, which is hard and brittle. The metal of which the Chinese gongs are made is composed of the same ingredients; it has the property of being malleable in some degree at a certain stage of its cooling, for the gongs are covered with marks of the hammer.

Copper exposed hot to the metallic vapour of zinc constitutes brass. The good quality of the brass depends much on the malleability and goodness of the copper employed in making it. There occur no ancient Greek or Roman instruments of this mixture; it is to be inferred, therefore, that they were not acquainted with it. It was employed in Europe after the fall of the Roman empire, as appears from the brass plates on tombs of the middle ages. The Chinese work in brass; and the only coins they have are pieces of small value composed

Copper. of brass containing much zinc. In Europe brass is used for culinary vessels; the ornaments of household furniture; the ornaments of horse-harness and of coaches; mathematical and philosophical instruments, for which also silver has the requisite physical qualities, but is too dear; the barrels of small pumps; the wheels and other parts of the machinery of clocks and watches; in the form of wire for making pins; and for some of the strings of harpsichords and guitars, the strings which give the higher notes being of iron wire. Brass is less tough than copper, it is brittle whilst hot. It is more easily melted and cast, and undergoes the action of the file and the turning lathe better than copper, qualities which render it convenient for the above-mentioned uses.

To obtain copper from the pyrites, otherwise called sulphuret, which is its most frequent ore, it is necessary to smelt the pyrites several times before the metallic copper is obtained free from sulphur; the slag or scoria produced in these smeltings is formed into large bricks, used in building in Wales and some other parts of Britain.

The chief use made of the native combinations of copper found in the earth is to extract the metallic copper from them; sulphur is sometimes manufactured in treating the copper pyrites. Some native oxides and native carbonate of copper are collected in the mines of Hungary, for the purpose of being employed in painting.

Oxide of copper obtained from the annealing that copper and brass wire undergoes, is used in dyeing.

In enamel colouring, oxide of copper, at a low degree of oxidation, produces an opaque red or brownish red enamel, called porporino. When the copper is more oxidated it gives a green colour in enamel colouring, in colouring upon earthenware and porcelain, and in stained glass.

Sulphate of copper, when concentrated or crystallized, is transparent and blue; it is manufactured for the use of the dyer and calico printer.

Nitrate of copper is also blue. It has been proposed to impregnate sticks of soft wood, such as poplar or fir, with a solution of this salt. These sticks, thus impregnated and dried, when they are lighted burn gradually to the end, and may serve as quick match for firing cannon.

Muriate of copper is green; that which is formed by direct solution of copper in muriatic acid is transparent, and soluble in water; but the native muriate of copper, with excess of oxide, is insoluble. This is found in Peru in the form of green sand, and being opaque, may be used in painting.

Verdigrise (*verdit-gris*) is an acetate of copper with excess of oxide. It is prepared in the wine districts of the south of France, by laying copper plates in strata alternately with the grape stalks and husks from which the juice has been pressed. The fermentation of the husks produces vinegar, which acts upon the copper. Verdigrise is used in painting, because it possesses, on account of its excess of oxide, the opacity necessary for making a coloured paste with oil; it is also used in dyeing. Crystallized acetate of copper is the acetate without excess of oxide; it is in green crystals, and is used in dyeing.

Scheele's green is an opaque precipitate, of a grass-green colour, composed of copper and arsenic. It is used in oil painting.

Copper || Copying-Machines.

Prussiate of copper is an opaque brown precipitate, formed by adding prussiate of potash to a solution of sulphate of copper, and may be used in painting. The colour, however, wants durability.

An Account of all Copper Imported into Great Britain in the year ending 5th January 1817.

	Cwts.	*qrs.*	*lbs.*
Unwrought in Bricks, Pigs, &c. -	0	1	8
Copper in Plates and Coins -	16	3	9
Old Copper for re-manufacture -	80	2	18
Copper Ore - -	15,051	0	0
Total quantity Imported -	15,148	3	7
Exported.			
Unwrought in Bricks, Pigs, &c.	18,194	3	14
Copper Coin - -	379	1	0
Sheets, Nails, &c. -	62,156	0	4
Wire - - -	157	3	7
Wrought Copper of all other sorts	23,388	2	24
Total of British Copper Exported	104,276	2	21
Foreign Copper unwrought, &c. Exported - -	1,840	0	1

(Y.)

COPYING-MACHINES. The celebrated Mr Watt, of Birmingham, in 1780, obtained a patent for a method of copying recent writings. The substance of his process is as follows: A sheet of thin unsized paper is wetted, and then laid between two woollen cloths, to take away the superabundant moisture. This paper is applied upon the surface of the fresh written letter, and the letter and wet paper, thus in contact, are passed through a rolling-press, or subjected to the action of a screw-press. The portable printing-presses made by Ruthven likewise answer well for this purpose. After the operation of the press, the thin paper is found to have received an impression of the letter reversed; but this impression is legible in the right direction when it is looked at through the transparent substance of the paper. The liquid used to wet the thin paper may be water, or a liquid composed, as Mr Watt directs, of vinegar, boracic acid, oyster shells, and gall-nuts. In this composition the gall-nuts seem to be the essential ingredient, their effect being to render the impression blacker, by combining with the superabundant iron which may exist in the ink wherewith the letter was written. The letters are to be written with writing ink, made in the usual way, of a decoction of gall-nuts, sulphate of iron, and gum Arabic. *Repertory of Arts*, Vol. I. p. 13. Watt's.

Mr W. Bell's patent was granted for a method of copying letters in a letter-book. For this purpose, a letter-book is made of thin unsized paper, and the leaf of the book on which the copy is to be taken is wetted; the letter freshly written is applied to the wetted leaf; the book is then shut, and subjected to the action of a screw-press. The impression of the letter is left on the leaf, and is read by looking at the other side of the leaf. The advantage of this method is, that copies of letters in a letter-book Bell's.

Copying-Machines || Copyright.

form a regular series, and are received as evidence in courts of law, where copies on a detached sheet would be objected to.

Wedgwood's.

Another mode of producing duplicates of writings is that for which Ralph Wedgwood, of Piccadilly, obtained a patent in 1806. He employs, 1st, A sheet of paper, over both sides of which printer's ink is spread; this is allowed to dry during six weeks, between leaves of blotting paper; 2dly, A smooth pewter or copper plate. 3dly, On the metal plate is laid a leaf of letter paper; over it the blackened paper before mentioned; and over this a leaf of thin paper, previously oiled, that it may be the more transparent. 4thly, On the paper thus disposed, the writing is performed by a style of agate, ground and polished to a smooth round point. The effect is, that the letter paper receives an impression from the blackened paper, and this impression is in the right direction, and constitutes the letter to be used as the original. The upper oiled paper receives an impression which is inverted, but may be read in the right direction, by looking through the paper. This constitutes the duplicate or copy. (*Repertory of Arts*, Vol. XXVII. 1807.)

Hawkins's.

A third class of copying machines is composed of those in which the hand of one writer gives motion to two pens at the same time, so as to produce two similar writings. Hawkins's polygraph, for which a patent was granted, is of this nature. It consists of two pens placed in a frame, and connected by joints, so that when any motion is given to the one pen, the second pen shall perform a similar motion. Whilst a person writes a letter with one of these pens, the other pen forms a copy or duplicate of the letter on a sheet of paper, to which this second pen is applied. The apparatus packs in the form of a portable writing-desk.

Brunel's.

M. Brunel obtained a patent for an instrument of a similar kind in 1799. (*Repertory of Arts*, Vol. XIII. 1800.)

Wedgwood's.

Ralph Wedgwood's apparatus, for which he obtained a patent in 1808, consists of a certain disposition of two leaves of paper, by folding or rolling. The part of the sheet on which a line of the original is written, is brought close to the part of the other sheet on which the corresponding line of the duplicate is written. The line of the original and of the duplicate are formed at the same time, by two pens fixed in the socket of one handle. The handle is held like a pen in the usual way. (*Repertory of Arts*, Vol. XXXI. 1809.)

Franklin's proposed method.

Franklin proposed a mode of copying letters, which consisted in writing the letter with gummed ink; this was sanded over with emery in powder. The letter, thus prepared, was laid upon a smooth plate of pewter, and passed through an engraver's rolling-press. The impression of the emery was left on the pewter, and printing-ink being applied to the pewter plate, an impression was to be taken, which was to serve as a copy of the letter.

Mode of copying lapidary inscriptions.

Inscriptions cut in marble or other stone, are copied by laying a sheet of white paper on the inscription, and by rubbing once over the surface of the paper a bunch of rags, dipped in pulverized black lead. If the inscription is cut on the stone, the letters on the paper appear white on a dark ground. If the letters of the inscription project above the plain surface of the stone, the letters on the paper are dark, and the ground is white.

(Y.)

COPYRIGHT.

Copyright denotes the property which an author has in his literary works, or which a bookseller, or any other person, may acquire by purchase, —a property founded, in either case, on the exclusive right to the publication of a particular work. The subject involves two important inquiries; one, the propriety of the obligation imposed by law on the publisher to sacrifice a given number of copies to our public libraries; the other, a much more extensive, and, in a public sense, more interesting question, the expediency of prolonging the duration of the exclusive property of a book.

Delivery of Copies to Libraries.

1. Recent discussions have made the public so familiar with the merits of the first question, that we shall merely give our readers a short history of the facts of the case. Printing became extensive in England about a century after its discovery; and it was in the year 1556 that a charter was granted to the Stationers' Company, an incorporation, consisting not of venders of stationary, in the present sense of the word, but of booksellers and printers, who, for their general benefit, determined to keep at their hall a register, in which should be entered the title of every new book, the name of the proprietors, and the successive transfers of the copyright. Bye-laws were enacted by the company; fines were levied on members acting in contradiction to their regulations; and, in course of time, these resolutions of the association were confirmed by a well known measure of government, we mean the licensing act of 1662; an act prohibiting the publication of any book, unless first licensed by the Lord Chamberlain, and entered in the stationers' register. In 1684 a new charter was issued to the company, partly for the purpose of securing the property of books, but more with the view of interposing the royal interdict on any publication at variance with the despotic government of Charles II. In the auspicious reign of William (1691), this act was repealed; but while the liberty of the press was restored, the door was unluckily thrown open to infractions on literary property by clandestine editions. It was in vain for the owner of a copyright to bring an action against the trespasser: he had no other protection than common law; he could recover only to the extent of the "damage proved;" that is, he could not adduce evidence of the tenth, or, perhaps, twentieth part of the damage suffered, as he could

Copyright.

not prove the sale of one copy out of twenty. This led to applications to Parliament in 1703 and 1706; but no act was passed until 1709, when, after much discussion, the sanction of the legislature was given to a bill, of which the prominent features were two: first, an obligation to deliver nine copies to as many public libraries; and next, a provision for guarding, by severe penalties, the property of copyright, during *fourteen years*. The public libraries entitled to the receipt of a copy each, were,

The King's Library, now transferred to the British Museum.

The Bodleian at Oxford, and the University Library at Cambridge.

In London, Sion College, or the Library of the London Clergy.

In Scotland, the libraries of the Universities of Edinburgh, Glasgow, St Andrews, and Aberdeen, with that of the Faculty of Advocates.

To these were added, by a subsequent act, in 1791, two Irish libraries, viz. Trinity College, Dublin, and the Society of the King's Inns in that city.

The delivery of nine copies of every new book was a heavy sacrifice, and booksellers were indefatigable in their efforts to evade it; delivering at one time only a single volume, and at others venturing to omit the ungracious duty altogether. Hence a necessity for new acts of parliament, more particularly those of 1775 and 1791. Still these acts were not sufficiently positive; and it having been decided in 1798 (in the case of Beckford *v.* Hood), that publishers were not prevented by such irregularities, from obtaining damages for pirated editions, they became more and more remiss in their deliveries. At last, in 1811, the university of Cambridge having determined to bring the question to an issue, brought an action for the non-delivery of Fox's history, and obtained a verdict. The booksellers, finding that this act was now no longer a dead letter, applied to parliament; but a committee of the House of Commons, appointed in March 1813, made a report in favour of their opponents; and in the succeeding spring an act was passed, confirming, in the most explicit terms, the claim of the public libraries, who were not even required to pay any proportion of the price of such books as they thought proper to require.

Term of Copyright; its successive variations.

2. For many years, we might more properly say for a couple of centuries, the property of a book seems to have been considered as permanent as the property of an estate; shares of literary works being bought and sold without any idea of their expiring. It is not till 1709, that we discover a trace of interference with its permanency, the act of that year defending it against intruders during fourteen years and *no longer*. The limitation, however, had no practical effect; copyright was considered permanent, both by the booksellers and the public,—nay by three out of the four judges of the Court of King's Bench, in the celebrated trial Millar *v.* Taylor, which took place in 1769, and led to a very memorable display of judicial erudition. The plaintiff charged the defendants with a trespass, in publishing an edition of Thomson's *Seasons*, of which the plaintiff was the sole proprietor. Lord Mansfield, with Judges Willes and Aston, gave an opinion in favour of the permanency of copyright, in which they were confirmed by Judge Blackstone; but one of their brethren, Judge Yates, took a very different course, and adhered resolutely to the literal construction of the act.

An action for a similar trespass was some time after brought before the Court of Session in Scotland; the London proprietor of a copyright claiming damages for an infraction by a provincial bookseller. (Case of Hinton *v.* Donaldson.) Here the majority of the bench were adverse to the opinion formerly delivered by Lord Mansfield, and discharged the defendant without a dissentient voice, except that of the well known Lord Monboddo. At last, in the session of 1773-4, the question came decisively before parliament, the booksellers having brought in a bill for declaring copyright perpetual. This bill passed the Commons, but was thrown out, after much debate, in the Lords.

Objections and Answers.

To avoid perplexity, we shall endeavour to comprise the *pros* and *cons* in these various discussions, in a kind of regular succession, adopting the plan of appending a rejoinder to each argument, as the best method of doing justice to both sides.

Objection. Ideas cannot be the object of property; they are not visible, tangible, or corporeal. (Judge Yates.)

Answer. Whatever admits of exclusive enjoyment may be property. (Hargrave.)

O. Another person may arrive, by his own process of thought, at similar conclusions, would you deny to him what you granted to his predecessor?

A. There is very little apprehension of such a coincidence; the plans and the results of study admit of as infinite variety as the human countenance; the same views, or the same conclusions, will never come from two persons, or even from the same person at different times, in the same language. At all events, an arbitrator or a court of justice can be at no loss to decide, whether a second publication on the same subject comes within the description of plagiarism.

O. A literary composition is undoubtedly the property of the writer, so long as it remains in MS.; but by the act of publishing, he gives it to the world; he lets the bird fly; his property is gone. (Judge Yates.)

A. He gives the public the free use of the knowledge contained in his book; but this is a very different thing from the profit as publisher. The ten shillings paid for a volume entitles the reader to the use of its contents, but can certainly give him no claim to the hundred pounds which may be expected from a new edition. (Lord Mansfield, Judges Willes, Blackstone, and Aston.)

O. It is not clear that common law ever sanctioned the exclusive enjoyment of copyright; the only titles appear to have been the royal patent and the licence of the Stationers' Company. (Lord Camden.)

A. It seems to have been always taken for granted by Chancery and other courts, that an exclusive right existed. There was a confirmatory example in the highest quarter; the King is perpetual proprie-

Copyright. tor of the right of publishing acts of Parliament and all public documents. (Lord Mansfield, Judges Willes, Blackstone, and Aston.)

O. The patentees of mechanical inventions possess but a limited term; none of them ever advanced a claim to perpetuity. (Judge Yates.)

A. Such patentees are much sooner reimbursed than authors; the fruit of their invention is of a more direct practical application. Besides, the stranger who makes a duplicate of a machine, incurs a much greater relative expence than the stranger who reprints an edition of a book,—in the one the materials form the chief part of the cost; in the other, they are comparatively insignificant, and copies may be multiplied by the thousand.

O. The statute of the 8th of Queen Anne, expressly limits the duration of copyright; it enacts that the protecting penalties shall be in force during fourteen years, and no longer. (Judge Yates.)

A. This is, no doubt, the apparent meaning of the statute, but the preamble of the act declares, that it is passed for the protection of literature; to make the act an instrument for curtailing a literary privilege would certainly be at variance with its general language. (Lord Mansfield.)

O. If such property be admitted for a time, is not the term of fourteen years sufficient? What good could the public expect from the writings of men so selfish as to call for a perpetual monopoly?

A. Monopoly is not the proper word; the object may be attained, as will be shown presently, under modifications which insure to the public a complete supply of books at reasonable prices.

O. "Glory," said Lord Camden, "is the reward of science, and those who deserve it scorn all meaner views."

A. Reputation is, and always will be, the grand stimulus to literary exertion, but it requires long-continued exertion; and if we do not enable a writer to live by his works, we confine the possibility of acquiring reputation to a very small class—to the rich, or to those who derive an income from other means. Such, in fact, has hitherto been the case; standard works have been attempted only by men who, like Gibbon, possessed patrimony, or who, like Robertson and Hume, arrived at the possession of income from other sources. No one imagines that our military or naval officers follow their profession for the sake of pay; yet no one would propose to abridge it on the ground of reputation being their primary object.

O. "It was not for gain," said Lord Camden, "that Bacon, Newton, Milton, and Locke, instructed the world."

A. Each of these distinguished men were obliged to trespass on the time devoted to literature, and to seek an income from public employments. How much better would it have been could they have given an undivided and uninterrupted attention to their favourite pursuits?

In comparing these various arguments, the balance is evidently on the side of the advocates of exclusive right in every point except one—the interpretation of the statute of Queen Anne. There the words, "fourteen years and no longer," are too pointed to admit of the construction put on them by Lord Mansfield. In the beginning of 1774, when the question came before the House of Lords, the judges attended and delivered their opinions at length, Lord Mansfield advocating the cause of permanency, while Judge Yates, now supported by his brethren, Baron Eyre and Baron Perrot, asserted once more the necessity of limitation. Thurlow, at that time Attorney-General, addressed the House, as a counsellor, against the perpetuity, and found an ardent auxiliary in Lord Camden; but the opposite side was ably supported by Dunning, by Solicitor-General Wedderburne, and by Lord Lyttleton. One party contended, that fame was the only true reward of literary exertion, while the others maintained, that without an adequate pecuniary provision, the public would remain deprived of many useful works. The House, however, appear to have been alarmed at the idea of perpetuity, and finally decided, that the exclusive right should last only "fourteen years, with a contingent fourteen, if the author happened to be alive at the end of the first period." Copyright.

The grand error on the part of the booksellers lay in demanding *perpetuity* instead of *prolongation*. The idea of perpetuity has in it something very serious, and will not be sanctioned by a legislature without the clearest proof of public advantage; it would be premature to ask it even in the present age. They ought to have urged the attention of Parliament to the number of years required to compose a standard work, and to the farther length of time necessary to give it effectual currency; appealing to the good sense of the Legislature, whether fourteen or even twenty-eight years were not wholly inadequate to remunerate these multiplied labours.

Foiled in the House of Peers, the booksellers determined to do what men always will endeavour to do when unjustly controlled—evade that which they cannot resist. They resorted to the alternative of giving an ostensible renewal to a work, by adding, at the end of the term of each copyright, notes and other appendages, which remained their property during another period of fourteen years, and afforded them a kind of guarantee in two ways: *first*, because a competitor, whatever he might do with the original text, could not touch the *addenda*; and, next, because the great body of publishers residing in London act as a corporation, and combine to give circulation to works thus edited, to the exclusion of rival impressions.

Partial Prolongation in 1814.

The law continued on this footing for forty years, the term of copyright receiving no extension till 1814. On that occasion it was soon apparent that the universities would carry the point of the delivery copies, and the only alternative was, to seek an indemnity in an extension of copyright to twenty-eight years; that is, by rendering the last fourteen *certain* instead of contingent. This was obtained, and here ends the historical part of our sketch.

Inquiry as to the advantages of a farther Prolongation.

We are now to enter on the grand question, of the "advantages of a farther prolongation of the

term of copyright;"—a question that has never yet been brought fully before the public, and which requires a considerable share of previous explanation.

We shall begin, by examining a very material point,—we mean the dispositions and habits of those with whom authors have principally to deal. And here, from long familiarity with men of business, we entreat the particular attention of our literary brethren; for, however anxious to be instrumental in procuring them relief, we must not hesitate to point out their errors or misconceptions. Of the surprising quantity of publications issuing annually from the press, not a tenth part are the production of writers of established character; the rest proceed from candidates whose reputation is yet to make. In what manner are booksellers to form an estimate of the mass of unknown MSS. thus laid before them? Their own habits are not those of study but of business, and they must consign the task of examination to friends who have been called not unaptly "literary tasters." Need we wonder that the patience of the critic should be put to a severe test by the mediocrity of the great majority of these performances, and that his report should, in general, be so little decisive, that the bookseller is led into the habit of putting one work on a par with another, and of subjecting them, in the mode of publishing, to the coarse application of a common rule? It has become the avowed practice to decline any other terms for a new work than those of defraying the paper and print in return for the manuscript, and in the understanding that the profit of the edition, *if there be any*, shall be shared between the bookseller and the author.

Now, this plan of publishing, however natural in the present state of the law, is replete with mischief to all parties, bringing forth a mass of books which ought never to have seen the light, and which, in truth, would never have been published, could the writer or publisher have foreseen their failure. It is a remarkable fact, disclosed in the inquiries arising from a late parliamentary discussion, that only "*one publication in eight is found to come to a second edition.*" (See *Evidence taken by Copyright Committee in* 1814.) The unfortunate limitation of copyright discourages literary men from the labour necessary to produce standard works; and the bookseller, tempted to assail the public by the attraction of novelty, goes on publishing books by the dozen, in the hope that some lucky chance may make up for his past disappointments.

All this shows that, in the great majority of cases, the contract between an author and a bookseller is made without previous *data*, and is nothing more or less than what is commonly termed a blind bargain. Dr Paley, on finishing the MS. of his *Moral and Political Philosophy*, tendered the copyright of it to a bookseller for L.300, and was offered in return L.250, exactly in the way that a cautious purchaser takes care to bid for unknown merchandise. During this negociation, it happened that a brother of the trade, apprised of the value of Paley's work, came boldly forward and offered L.1000 for the copyright. The author consenting to give the party first in treaty the previous option, the latter now saw the matter in a new light, and ended by paying four times the the amount of his original offer.

No notion is more general among authors than that booksellers make rapid fortunes at their expence. One writer has published, that Jacob Tonson and his nephew died worth L.200,000 (D'Israeli's *Calamities of Authors*, Vol. I. p. 29); and not one reader in twenty will stop to question the accuracy of the allegation. It is our firm belief that such a sum was never possessed by any bookseller, or partnership of booksellers, that ever existed. Among them, as in all lines of business, there are examples of considerable capitals, but these are only realized in the case of long-established concerns, and after a progress of acquisition infinitely slower than the angry imagination of a disappointed author allows him to believe. In his eagerness to take for granted that his publishers are getting rich at his expence, he forgets the history of the fathers and grandfathers of the present men, and omits to mark the slow steps by which they paved the way for the eventual rise of their descendants. He fails, likewise, to scrutinize another material point, namely, the *quantum* which a close calculator would deduct from the estimated fortunes so liberally assigned by current report to booksellers. The latter, like all men in business, are desirous of passing for affluent; but, if so few publications are found to be successful, must there not necessarily follow a large abatement from the imagined extent of their annual gains? It is, on various accounts, a matter of regret, that the limited profits of bookselling business should not be better understood by literary men. The discovery of it would remove the film from their eyes, would lessen greatly their habits of complaint, and would lead to cordial co-operation for redress of their common grievances. We may with confidence assert, that a small offer from a bookseller, as in the case of Paley, is indicative, not of a design to overreach, but of an apprehension that, to give more, would be to injure himself. On the other hand, we are by no means disposed to launch out into a panegyric of the liberality either of particular individuals, or of the body at large. Like other men of calculation, they naturally mete out their advances, not by attachment to the writer, but by the extent of the expected return. A large allowance for a finished book denotes a confidence of extracting a still larger from the public, while the scanty, and apparently niggardly, payment of an unknown author, is a token of the fear and trembling with which a bookseller handles a production of doubtful promise.

The customary agreement between a bookseller and a new author proceeds as follows: The latter having prepared a work, of which he has high hopes, but in which he has not had either guidance or advice, sets out by making an offer of his MS.; and, after some time taken for consideration, is answered, that his name not being yet known to the public, the publishers cannot take on themselves to make him a payment for his labour, but are willing to give it to the world on their joint account. This leads to a compact in terms somewhat like the following:

It is agreed between Messrs Y. and Company, booksellers, and Mr Z. that Messrs Y. and Com-

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pany shall print and publish for their account, jointly with Mr Z. in two volumes octavo, his historical work on ———— Mr Z. supplying the manuscript, and Messrs Y. and Company taking on themselves the paper, printing, and other publishing charges. The statement of the account to be made up every year at midsummer; and when, after deducting the various publishing expences, there shall appear a balance of profit, the same to be equally shared between Mr Z. and Messrs Y. and Company. The books to be accounted for at the regular trade sale price.

The publication now takes place, and in a twelvemonth after, an account is made up in the following form:

Dr.	History of ———			by Mr Z.			Cr.
Printing 60 sheets at 40s.	L. 120	0	0	750 Copies printed, retail price 21s. the price to the trade 15s.			
Over-running and corrections - -	9	0	0	150 copies sold and delivered in sheets, at 15s. -	L. 112	10	0
Paper, 90 reams at 30s.	135	0	0	Balance at Dr, carried to next year -	184	0	0
Advertising - -	30	0	0				
Boards for 25 copies delivered to the author's friends	2	10	0				
	L. 296	10	0		L. 296	10	0

Next year the account is considerably shorter, the charges consisting only of advertising and interest of money; but the attraction of novelty having gone off, the sale is also less, and does not probably exceed eighty copies, leaving still an adverse balance of L.100. The bookseller goes on with mercantile punctuality to render him a farther account, but the sale is now in a state of progressive decrease, and does not, for the third year, exceed 50 copies, leaving still an unfavourable balance of L.80. The author now loses patience, and entreats the bookseller to relieve him of all responsibility, by taking over the remaining copies, and considering the account closed. Such is the fate of five-sixths of the books, great and small, that come before the public. Composed without the benefit of experience, they are unprofitable to the publisher, uninstructive to the reader, and discouraging to the author. If we are suspected of stating an extreme case, let another be supposed, in which the author is less of a novice, and in which a bookseller, from confidence equally in him and in the subject, ventures to make an advance of money, and to agree to pay a fixed price for the copyright. An arrangement is made for bringing out the work against a given time, and the writer proceeds with all the ardour attendant on a new enterprise. Authors, however, were never remarkable for accurate calculations, or rather their undertakings are almost always found to require more time and labour than is anticipated:—the prescribed time expires, and the bookseller agrees to postpone it for another twelvemonth. This also passes away; the publishing season draws near; the work is still unfinished, but the author is impatient of farther labour, and the bookseller thinks it high time to get a return for his money. The work goes to press, and comes out without either a correction or an acknowledgment of its imperfections, unless the author be particularly modest, in which case the public is requested, in a well turned apology, to make allowance for his multiplied avocations and the urgent nature of the subject. This is the case with almost all the better class of our new publications; the sale, in such cases, is somewhat less unfavourable than the specimen given above; but four or five years are requisite to run off an edition, and, on coming a second time before the public, it is necessary for the author to do what should have been done at first—revise and correct the whole. A second edition comes out, but under considerable disadvantages; the attraction of novelty is gone or greatly impaired; the number of readers is lessened by those who have purchased copies of the first edition, and the character of the book has been estimated, in Reviews and elsewhere, by an unfavourable standard. The bookseller is thus curtailed of profit, the author of reputation, yet each has the happy gift of throwing blame off his own shoulders; the publisher attributing the failure to the distraction of the public attention by some unlucky novelty, while the other vents his complaints on the incurable frivolity of the age. In truth, neither of the parties is much to blame; their conduct is the natural result of their situation; the haste of authors and the acquiescence of the booksellers are mainly owing to the short-lived tenure of the fruits of their labour; the habits of the one and the calculations of the other having been all along adapted to this state of things.

Is there then no remedy for so mortifying a state of things? no method of relieving the public from such an unprofitable expenditure of time and attention?—Some have been desirous to call in the patronage of Government, and have argued, that literature can never, like the coarser objects of industry, find adequate repayment in the fruit of its exertions. It is, indeed, a current subject of complaint among authors, that there should not be a larger proportion of provisions for life appropriated to literary men. *Sed non tali auxilio*—whatever be their distress, we beg to deprecate any interference on the part of Government. No engine is so formidable as the press in the hands of an arbitrary or artful ruler. Look at the degraded picture exhibited, during a succession of years, by the French press; and you will find men, who, under the auspices of freedom, would have acted an independent part, tempted, threatened, and gradually compelled to become the advocates of a tyrant, and to participate in the guilt of rivetting the chains of their countrymen. It is in vain, even for a liberal legislature or a disinterested sovereign, to attempt to make up for the deficient reward of literary labour, by granting pensions or creating places for men of letters. These measures, though apparently beneficial, carry with them all the disadvantages of irregular and unnatural interference. A literary man promoted, as is not unusual in France, to a government employment, is withdrawn from his proper sphere of utility; he becomes lost to general reasoning and liberal views amid the endless details of practical routine. The pension granted to Johnson by Lord Bute was generally approved, both as the fair reward of past industry, and as a seasonable relief to pecuniary difficulty; but, what was the consequence? it fostered his natural indolence, prevented the composition of farther works, and, by enabling him to live in idleness, rendered him per-

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petually dissatisfied with himself. Had the property of his literary labour been permanent, he would have received twice as much from the booksellers, and might have continued his proper pursuits under circumstances progressively improving, without incurring the humiliation of dependence, or degrading his name by the composition of party pamphlets.

It is equally vain for zealous friends to attempt making up for the inadequacy in question, by procuring private subscriptions for a work; for, whatever may be the success, in a pecuniary sense, the step is humiliating to the author, is liable to abuse, and is, besides, an interference with the proper business of a bookseller. One of the most splendid of such examples was Pope's translation of *Homer;* an undertaking where the importance of the task and the talents of the translator called equally for liberal remuneration. Pope was perfectly ready to sacrifice several precious years for the sake of eventual competency, and he found in his friends, particularly in Swift, a most zealous promoter of his views. Proposals were circulated, liberal subscriptions were obtained, and a favourable bargain made with the bookseller: the translation of the *Iliad* was executed, and will for ever remain a proof of the perseverance to which an author may be prompted by the love of fame, when relieved from pecuniary pressure, and enabled to give long continued labour to his task. So far all was well but the success of this first undertaking induced Pope to resort to the same method for publishing a translation of the *Odyssey*, which proved far inferior; being performed either hastily by himself, or by two coadjutors, whose respective contributions, though not altogether concealed, were unfairly represented to the world. Could such an abuse have taken place had subscription been out of the question, and had the remuneration of Pope been proportioned to the eventual sale of his book? The public would, in that case, have had a translation of equal merit with its predecessor, and Pope would have been spared the reproach of a literary imposition. The least exceptionable mode of rewarding literary eminence is by church preferment in the southern part of the kingdom, and by admission to professorial chairs in the north. But the extent of both, particularly of the latter, is limited, and does not always place a man in that station where he can be most useful, or in the mode of employment most congenial to his habits. Both besides require more of connection, of interest, and of management, than commonly falls to the lot of a retired student.

The only effectual plan is, to find the means of relief in the prosecution of literature itself; to relieve it from existing shackles, and to allow every writer to reap his reward in the sale of his books, exactly as we do in other kinds of employment. This is all that literature wants, and all that it is good for her to have. She will then make no claims to patronage from Government—no appeal to the subscriptions of private friends—nor will appointments in the church, or at universities, be an object of indecent contention; they will be coveted by a smaller number; by those only whose particular habits fit them for such situations. Perpetuity of copyright is as much the right of the author or purchaser of a book, as of the builder or purchaser of a house; and the public will never reap its full harvest of advantage from literary compositions till the law be made to confirm the claim of equity. But, as this opinion is as yet far from general, the true plan is to desist from pressing it to its extent, to demand only the grant of a specific period, and to leave the public to enact perpetuity at a future time, when it shall have had practical and undoubted evidence of the beneficial effect of prolongation.

Let us first see if we can take a useful lesson from the example of our Continental neighbours. In France, copyright has of late received several prolongations; at first limited to the author's life, it was extended in 1793 to ten years, and in 1805, to no less than twenty years after his death. Taking twenty years as the average of life after the publication of a work, we have here, in the whole, a medium term of forty years, which is considerably longer than ours. But the grand practical example is to be found in Germany. In that country, *copyright is perpetual;* and though the sales of editions are very limited, in consequence of the facility of importing clandestine impressions, from the territory of neighbouring princes, such is the benefit of permanency, that Germany sends forth more works of lasting use than any other country in Europe. Compare their performances in Statistics and Geography with those of France, England, or Italy, and we shall be surprised at their superior research, and their careful examination of the necessary documents. It is at present proposed to effect a most important improvement in the state of book property in Germany, by rendering the protection general throughout the empire; and by enacting, that a clandestine edition published in a different state shall be subject to the same penalties as if published in the country of the writer. The great powers, Austria and Prussia, are understood to favour this measure, and some objections raised by the lesser states are likely to be overcome; and if the decision of the diet be speedy, Germany will take the lead of all Europe in the production of standard works.

State of Copyright on the Continent.

There is evidently no reason that the term of book property should have a reference to the probable time of an author's life; it is much more equitable to prolong it to a considerable time after his death, as a provision for a family deprived of its natural protector. Our present term of 28 years appears, at first sight, no inconsiderable tenure; but the circulation of literary works is often only beginning to become considerable when the property is drawing to a close. *Paradise Lost* remained in comparative obscurity for many years; and, on coming nearer our own times, we find Hume's early works, and even the first volume of his *History*, falling deadborn from the press; and Smith's *Wealth of Nations*, the labour of half a lifetime, going through only two editions in the course of eight years. No wonder, then, that a bookseller should pause before giving a large price for a short-lived possession. But, prolong copyright, and you relieve him from the necessity of laying stress on the sale of this or that season; you direct

Inadequacy of our present term.

his hope to eventual and permanent circulation; and you put it in his power to pledge himself for a considerable sum, because he is justified by the prospect of the return. An author, thus supported and encouraged, will no longer scruple to give year after year to studying a subject thoroughly, and bringing out his book in a finished state.

We shall next put the principal suggestions which have occurred to us into a specific form, less under the idea of their forming the basis of a legislative measure, than as a convenient mode of stating the substance of a case.

Sketch of the proposed alteration.

Grant, in all books to be hereafter published, a prolongation of copyright for twenty-two years, making in the whole fifty years. Appoint a commission (with power of reference to a jury) to act in all cases where the owners of copyright withhold publication, or confine it to an expensive form. Empower this commission to order the publication of such works, in the form which they judge most proper, and without any other obligation towards the proprietor of the copyright than that of paying over to him or his representatives the proportion of profit accruing, by the practice of the trade, to the owner of a copyright. (*Quarterly Review*, Vol. VIII. p. 112.)

The power of this commission to be operative only for the additional term (twenty-two years), without application to the existing twenty-eight.

The act of 1814 would thus remain in force.—Should it however appear, in the progress of the discussion, that the additional prolongation made it necessary to provide for the interest of the public, or of the minor booksellers, the power of the commission might be made applicable to a certain portion of the twenty-eight years. Such interference would probably not be wanted, the interest of the copyright owners being the same as that of the public; but the former would, at all events, have no reason to complain, the additional prolongation being a very substantial equivalent for any curtailment of their powers.

The grand objection hitherto has arisen from an idea, that, to prolong copyright, was to prolong the power of the owner to deal with the public as he chose. Nothing, however, is easier than to separate the two, preserving to the bookseller his property, and giving the public the right of calling for editions of his book, in the manner most suited to general convenience. This seems sufficiently explained in the above provision; and the only matter of surprise is, that it should not have been sooner acted on.

This clause would put book property on so plain and equitable a footing, as to open a prospect to another and very desirable arrangement—*a community of copyright between this country and the United States;* that is, a mutual compact that "the publisher of a book in the one should possess the property of it also in the other," subject always to the interference of a commission or jury in each country, who should take care that it be given to the public in a cheap and convenient form.

Its Benefit to Authors.

Such is the plan of the proposed alteration. We are next to consider its probable effects;—and first, as to literary men. They certainly feel sore at the obligation of sacrificing eleven copies of every book to the public libraries. A prolongation of copyright would go far to remove this uneasy sensation; but we would urge it on higher grounds; and here it is fit to state, that our arguments are not at all intended to favour a mercenary spirit. Those persons who write merely for money, find, at present, an ample stock of employment, in compiling, abridging, and plagiarizing; they are dead to the feeling of reputation; and incapable of that judicious and honourable calculation which shows that the true way to attain either fame or competency, is to be sparing of early publications, to study in silence, and to aim only at ultimate success. Such men do not properly belong to literature; they have been cast into it merely as a refuge, and because its pursuits bear a certain connection with their early education. The men who would be benefited by the change would be a very different class; they would be those who embrace literature as others embrace medicine, law, or the church, with the intention of following it as a profession; who make allowance for the years that must be passed in unproductive study, and who do not repine at the postponement of their reward, provided it be not eventually withheld. The proposed alteration would operate in their favour, not by gratifying a mercenary spirit, which literature never engenders, and which, if it previously existed, would be modified, perhaps cured, by such pursuits; but, by enabling the individual to pursue his task, without discouragement, and without feeling that, by gratifying his personal predilection, he is doing an injury to his family. Improve his circumstances, not that he may amass money, but that he may have the means of support during the long labour necessary to reputation. More is not to be desired; the wants of literary men are few, their residence,—their plan of life,—their mode of bringing up a family, ought all to be such as to recall the philosophic simplicity of former days.

What a reproach to Modern Europe, that, with all the benefit of extended circulation and the invention of printing, our literary compositions should not have surpassed those of the ancients! Does not this argue, that there must exist somewhere an unhappy counteraction to our advantages? In number of studious men we far surpass the fairest days of Greece and Rome; but few of them, comparatively, become writers; they meet a deal of difficulty and discouragement in their attempts to address the public, and the result is, that their knowledge expires with themselves. Such will be the case until an effectual change be made; we shall have the mortification of seeing men capable of enlightening the world and accelerating the progress of improvement, doomed to waste their time in teaching pupils, or relinquishing literature for the pursuit of professions productive only of money. Others who prefer the gratification of their taste to all considerations of property, must be content to live on a trifling pittance abroad, or in a corner of their own country, remote from libraries and the pleasure of literary intercourse.

To make literature a profession for life, is almost a new project; for hardly any have set out with the in-

tention of making it their sole object. They have, consequently, proceeded without a settled plan,—have arrived at no definite method until advanced in years, and have seldom, if ever, thought of drawing up instructions for the guidance of their successors. Observe in mercantile business, in public offices, and in the law, how labour is methodized and subdivided; in what manner the mechanical and uninstructive part is made to devolve on inferior assistants, and the time of the principal reserved for general views and important decisions. In literature, any thing of the kind that has yet been attempted, is in its infancy; yet the same plan is applicable; and were authors so far put at their ease as to be enabled to make an undisturbed apportionment of their time, they would soon learn to make great improvements in their mode of study.

Its Benefits to Booksellers.

In the present situation of copyright, a bookselling house generally keeps the property of a book till towards the end of the twenty-eight years, when a sale takes place on the plan of interesting the trade at large in the preservation of the property. The work is put up to auction at the Chapter coffee-house, in sixteenth or thirty-second shares, and disposed of to a number of different purchasers, who all become interested in supporting each other, and in discouraging the sale of rival editions, printed at Edinburgh, Dublin, or elsewhere. In this manner the property of Cowper's *Poems* is said to have been sold in October 1812 for L. 4160. The shares of all our *standard* writers are thus vendible, and for sums which would surprise those who do not happen to be initiated in the mysteries of the trade. Hence the great cause of the indifference of booksellers to the question of prolongation, for they consider themselves as enabled, by this happy expedient, both to baffle the tyrannical limitation of the law, and to keep within bounds the demands of authors. "At present," say they, "we are sure of having the power of purchasing shares in any valuable book property; our profits, indeed, are considerably lessened by the cheaper printing of booksellers residing out of the metropolis; but the extent of connection of us, the London traders, is such as to give a tolerable degree of certainty to the value of our shares. Were authors assured of a prolonged term, it is questionable whether we should so soon have the option of buying copyrights; at all events, we should pay dearer for them." This reasoning is plausible, but, like the general conclusions of most practical men, will be found to be drawn from a narrow circumference. Whatever be the duration of copyright, the property of it, in nineteen cases out of twenty, must be vested in the bookseller. How can authors have the means of running the risks, or waiting year after year, the tardy returns of sale? Must they not continue to exchange these formidable contingencies for a specific allowance in the shape of ready money? To write books is one thing; to sell and to hold the property of them is another. The one is the province of the retired and sedentary student, the other of the man of activity and capital. Again, as to augmentation of price, booksellers would, indeed, in the event of a prolongation, find it necessary to increase the remuneration of good writers; but this increase would be repaid them threefold in the augmented value of their editions, which would, in that case, embrace the circulation, in all probability, of the United States. Printing, at least the printing of English copyrights, cannot, in time of peace, continue in America, unless we persist in our present system. Give encouragement to our own writers, and the compositions offered to our booksellers will soon be of a stamp that will rival the impressions of France, where two or three thousand copies are struck off for one thousand in England. Observe the effect of such a change in facilitating the recovery of the drawback on paper; a drawback at present of little benefit to our exporting booksellers, because the books shipped to America are frequently in such petty lots as not to defray the expence of the debenture. These considerations are of the highest importance at a time when the re-establishment of peace and the commercial activity of the Continent of Europe, gives reason to apprehend the printing of rival editions of our standard books for the American market.

Cheapness is not to be sought by the inferiority of type and paper; but it would be the result of those progressive improvements, which would soon take place among us, were things left to their natural operation. An increase in the size of an edition, implies the practicability of reducing the price to the public. Of the various benefits arising from cheapness few of us are sufficiently aware, accustomed as we have been to progressive enhancement in this age of war and expenditure. It would enable us both to supply the foreign market and to increase greatly our circulation at home, by inducing individuals to buy books which they would otherwise borrow, and to have always at hand those to which they would otherwise only have occasional access.

What is the ordinary course of the business of a great publishing house? A large proportion of the books they send forth pass unnoticed, and hardly defray the paper and print. What loads of unsaleable volumes encumber their warehouse! What a world of expence do they incur for unproductive advertising! The success of the house depends on the very few works of standard merit (perhaps one in forty) which obtain extensive sale, and form a counterpoise to their ill-starred brethren. Now, the effect of a prolongation of copyright would be to increase very considerably this select number, and to afford on a large, that benefit which is now enjoyed on a small scale. Booksellers have merely to look around them to see that those publications succeed best where the encouragement of the writer is most liberal. This has been strikingly exemplified in the principal Reviews and other conjunct compositions of the day; and how much greater would be the exertion in the case of a separate publication,—a case where the personal fame of a writer is so much more at issue? The expence of paper, print, and advertising, are as great on a bad as on a good manuscript, and it would in time become a rule with our leading booksellers to publish none but first-rate books:—adhere to this, and you may safely dispense with repeated and expensive calls on the public attention,—

Copyright. the name of your house will do more than everything else.

Another and by no means inconsiderable advantage of the command of a valuable manuscript, is the power of obtaining, either in money or otherwise, an allowance from a French or a German bookseller for the use of the English sheets, for the purpose of translating,—a point hitherto little attempted, in consequence of the trifling nature of most of our publications.

Booksellers complain, and probably with truth, of the vanity and unreasonableness of authors; but the literary line has many attractions, and whenever you satisfy men that they will not doom themselves to a life of poverty by following it, you may be assured that you will soon have to transact with a very different class.

It is usual with booksellers, when treating with an author of reputation, to make their bargain with reference to successive editions, that is, they pay a certain sum for the first; a farther sum when a second is called for; and a final payment on the appearance of a third, generally completes the purchase of the copyright. This plan would be regularly acted upon, could the bookseller have confidence in his literary contractor. It reduces the risk of the former, while, to the author, it affords the gratification of prospect, and gives him the strongest motives to render his book worthy of permanent favour.

Such is the state of the case as regards the elder brethren of the trade,—the principal publishers; but we must address a few words likewise to a numerous and, in general, a respectable class,—the printers and lesser booksellers. These persons may apprehend that a prolongation of copyright would prove a continued suspension of their power of coming forward with cheap editions; but we refer them to the clause in the above sketch of the proposed act, which might be so framed as to allow any bookseller who choose to make the speculation, to print an edition of a work on his obtaining the assent of the proprietor of the copyright, or, failing that assent, on his getting the sanction of the committee or jury authorized to settle disputed points. What sum should be paid to the copyright owner, is a point for farther consideration, depending on the nature of the work, its size, its popularity; but the custom of the trade would supply the proper rules, and the principle, once established, the arrangements would suffer no greater difficulty than other changes in business.

We are next to call on the lesser booksellers and printers to take a comprehensive view of their situation, and to mark that progressive change and extension of the bookselling business, which shows that there is no ground for keeping up ancient jealousies, or for considering the interest of one branch as different from that of the others. Look back to the history of the trade, and observe how it has gradually, and without the aid of interference, divided itself into a variety of distinct branches. Booksellers combined at first the sale of stationary with that of books; hence the Stationers' Company. In process of time they relinquished, in great towns at least, this unnecessary appendage, and, after a farther lapse of years, divided the wholesale book business from the retail. Progressive extension led next to a distinction between the publishing and the old book departments; and we have at present in one house (the house so well known as the publishers of Hume and Robertson) the example of an establishment avoiding all business, even wholesale, except what relates to books printed for their own account. These subdivisions tend exceedingly to facilitate business; they cause it to be done both better and to greater extent. The longer our experience, the more we are satisfied, that the repetition of employment is the only true road to success, and that we cannot more effectually clog our progress than by attempting the conjunction of dissimilar undertakings. The farther course of things, particularly under an extension of the term of copyright, would lead to the formation of establishments on a still more simple plan; some bookselling houses would confine themselves to the mere management of copyrights, and leave not only the printing, but the sale, to the trade at large. Such houses would merely stipulate a certain payment for leave to print an edition of a given size and form, and transfer all details of management to the undertaker of the speculation. Is this a prospect calculated to alarm either the printers or minor booksellers? Does it not tend to show, that things, when left to their natural course, fall invariably into their true channel, and render superfluous both the care of the legislature and the bye-laws of corporations?

Benefit to the Public. We come next to consider the interest of the public in the proposed regulations. We are not aware, that there exists at present complaints of books being capriciously withheld, or confined to expensive forms. In the case already quoted, Cowper's *Poems*, there were on sale at one time, and that *before* the expiration of the copyright, no less than five editions: viz.

One in 8vo, with plates, L. 1, 6s.
One in 8vo, without plates, L. 1, 1s.
One foolscap 8vo, 14s.
One do. of inferior print and paper, 7s.
One 12mo, stereotype, 9s.

Nothing, moreover, can be clearer to a man of business, than that the dearer an edition, the fewer the purchasers; and that the true plan is to meet the demand of all classes with as little delay as possible. This we see repeatedly exemplified in the case of new books, where an 8vo edition is brought forward before the sale of the 4to is completed; but as all booksellers might not be equally accommodating, the plain alternative is to invest *a commission with explicit powers to interfere*. This will form a full and conclusive answer to those arguments which Judge Yates on the bench, Lord Kaimes in the Court of Session, and Lord Camden in the House of Peers, so strongly urged against giving what they termed the "continued monopoly of a book." These distinguished persons were not aware of the difference between the preservation of property and the continuance of control; they could not see by intuition what it has taken no small share of time and reflection to discover.

The existing restrictions as to the term of copyright, tend only to open a door to abuse, by inducing an author to make his work less perfect in the first instance, on the plan of affording him an easy method of renewing the exclusive property. Gibbon did not scruple to write to his publisher, that a thorough revisal of his history would form "a valuable renewal of the copyright at the end of the term." * Booksellers follow this plan avowedly and habitually; and it is the remark of a very intelligent writer on the subject of copyright, that, unless a change take place, our purest and best authors will become so disfigured by annotation, and increased in price by increased bulk, that the early editions will be called for. †

We by no means assert, that the proposed change would stop the appearance of trifling works, since every man must be allowed to waste his time and his property as he chooses; but it would surprisingly increase the number of good books, prompting many, who are at present entirely discouraged, to become authors, and inducing others who labour, but labour with haste, to give a finish and attraction to their performances.

It is long since Dr Johnson pronounced us "a nation of readers," yet we are still extremely deficient in *standard works*, and on subjects too where we ought to have been long since amply supplied. Have we a good *general* history of Ireland or Scotland, or even of England? No wonder that we should still be deprived of such works when we calculate the time, labour, and expence required in their composition. Now, that public records have become so voluminous, and the transactions of nations so complicated, whoever undertakes to do justice to such topics will find himself subjected to a variety of expences; he must set apart two, perhaps three, years for what apparently requires one; he must have his residence in the vicinity of great libraries; he must carry on an extensive correspondence; he must employ clerks in making copies of official documents and family papers. The same observations are applicable to scientific labours. At present, no bookseller can afford to indemnify a writer for the years he would be disposed to bestow on a favourite but insulated branch—he must have a work on a subject of general interest; that is, one which will take in a number of topics, without going to the bottom of any. But prolong the term, and afford a prospect that a well written book, even in a limited department, will make its way, and the bookseller will find himself justified in offering to the author a sum which will enable the latter to indulge in his predilection for the branch in question. This point is of great consequence, for almost every author has a favourite subject, which he would cultivate with great zeal, did not necessity oblige him to turn aside to popular topics, for the sake of a livelihood. We have known works that might have been completed in two or three years, postponed from interval to interval, so as to occupy seven, eight, or nine, in consequence of those unwelcome avocations.

The more a man of taste and judgment studies the true nature of composition, the more he becomes attached to simplicity; he loses all relish for flowery diction; he learns to chasten his early predilection for ambitious passages: for point and antithesis he substitutes the plain language of the Grecian and Roman models. Such a style is calculated to be permanent, but may not for sometime be popular, perverted as the public taste is by a habitual tone of exaggeration and inflation. The reward of such writers is thus to be found only in length of time. Grant but this, and you will accomplish a total change in the character of new books, rendering the writers indifferent to whatever may be called tricks of composition, and directing their attention to the plain, the solid, the permanent. What a prospect is here opened both of improving our national style and of diffusing useful information! This is one of the many things which show that the benefit of one part of the community is the benefit of all; and that, whenever we are enabled to sift a subject to the bottom, and to view a question in all its bearings, we find, that the existing evils are the result of our own prejudices or mistaken regulations. We have treated this subject with reference to four distinct parties;—authors; publishing booksellers; the lesser booksellers with the printers; and, finally, the public; yet we challenge any opponent to produce a single point in which the advantage of the one is not found to coincide with and promote the advantage of the others.

How has it then happened that a case calling so strongly for amendment has not hitherto been fully brought before the public? The reasons are the following:

Publishing booksellers have been, and still are, unconscious of the improvement which it would produce in literary composition.

The lesser booksellers and printers were not aware of the practicability of combining prolongation of copyright with freedom of composition.

The parliamentary opponents of the measure, such as the late Lord Camden, were equally unaware of the possibility of the provision in question.

And as to literary men, their error has been partly in want of co-operation, partly in asking too much, by urging at once a claim to perpetuity.

But is there now any prospect of the adoption of such a measure? The progress of improvement is slow; our legislators have not leisure to study such matters to the bottom, and our practical men are, in general, wedded to ancient usage. At the same time, there are strong reasons to hope, that the question, if taken up by a spirited and persevering member of Parliament, will eventually be carried. The universities afford an encouraging example. They have long possessed copyright without abusing it. Booksellers are beginning, particularly since the

* Correspondence from Lausanne, annexed to his *Memoirs*.

† *Address to Parliament on the Claims of Authors*, by a Member of the University of Cambridge, 1813.

peace, to take a wider view of their business; to aim at exportation, to lessen their prices, and to seek an equivalent in a wider circulation. As to authors, their object is completely the same with that of the public—extended Circulation. Precedent, likewise, is in favour of the measure. We have the example of successive prolongations of copyright in this country and in France; and a most encouraging proof of the effects of perpetuity in Germany. Finally, it may be safely urged, that, until some such measure is adopted, the public will receive very few standard books. (D. D.)

Copyright || Coralliniadæ.

CORALLINIADÆ. Under this head we propose to treat of these marine substances, named by Linné *Corallinæ*, whose situation in the system of nature has not been satisfactorily ascertained by naturalists, some having referred them to the animal, and others to the vegetable kingdom. The more recent writers, Bosc, Duméril, Lamouroux, Desmarets, Lamarck, and Le Sueur, for the most part, place them with the zoophytes without hesitation; and even Cuvier, who has not fully satisfied himself as to their nature, treats of them amongst the zoophytes in his *Règne Animal*, which indicates the bias of his mind on the subject. Pallas, Robert Brown, and Blainville, are inclined to refer them to vegetables; indeed, Brown has little if any doubt on the matter; and since they have not been observed to contain polypes, we are very unwilling to treat of them as animals, and therefore give an account of them under the head *Coralliniadæ*, a patronymic title derived from the most prominent genus of the group.

We shall give the characters of the Genera, and under each shall mention the opinions of different authors.

Tabular View of the Genera.

				Genera.
Stalk	distinct, abrupt,	simple terminated by	an umbell, - - - -	1. Acetabularia.
			articulated; terminated by several pyriform processes attached by their bases, - -	2. Polyphysa.
			a flabellum marked with transverse curved lines,	3. Udotea.
			a pencil of dichotomous articulated branches,	4. Nesea.
	Articulated and not abrupt; terminated by articulated branches which are	fistulose, cylindric, dichotomous, - - -		5. Galaxura.
		capillary, dichotomous, - - - - -		6. Jania.
		compressed trichotomous, - - - - -		7. Corallina.
		cylindric dichotomous, the joints moniliform, - -		8. Cymopolia.
		furnished with a horny substance between their joints, -		9. Amphiroa.
		furnished with flabelliform joints, - - -		10. Halimeda.
	none - - - - - - - - - -			11. Melobesia.

All the above genera are placed in the order *Corallinæ* by Lamouroux, and under the title *Corallina* by Cuvier. They resemble plants, are generally jointed, and are formed of two substances, the one internal, the other external. The central part is fistulose, fibrose, or compact, and is surrounded by the cortical substance, which is calcareous. From this structure, Cuvier seems to have determined to place them near the *Gorgoniæ*, whose inhabitants are very well known to be zoophytes.

Gen. 1. ACETABULARIA. *Lamouroux.*

OLIVIA. *Bertolini.*

ACETABULUM, *Lamarck, Cuvier.*

Stalk distinct, long, filiform, simple, fistulose, terminated by a striated-radiated umbell.

Sp. 1. *Crenulata.* Plate LXVI.

Tubularia acetabulum, *β. Gmelin, Syst. Nat.* 3833.

Acetabularia crenulata. *Lamor. Hist. Polyp. Corall. Flex.* 249.

Acetabulum Caribæum. *Lamarck, Hist. Nat. des An. s. Vert.* 151.

This species is found in the West Indian seas, where it is very common. There is another species, A. Mediterranea, that is not uncommon in the Mediterranean, the supposed animal of which has been described by Donati, who mistook some parasite for the tentacula. *Cuv.*

Gen. 2. POLYPHYSA. *Lamarck, Cuvier, Lamouroux.*

Stalk distinct, long, filiform, fistulose, composed of confluent joints, terminated by eight or twelve pear-shaped processes, attached by their bases.

Lamarck has referred this and the preceding genus to his vaginiform polypes, along with *sertularia*, &c. and mentions tubes and cells, which we cannot perceive in our specimens.

Sp. 1. *Aspergillosa*, Plate LXVI.

Polyphysa australis. *Lamarck, Hist. Nat. des A. s. V.* 152.

Polyphysa aspergillosa. *Lamouroux*, 252.

Fucus peniculus. *Turner, Hist. Fuc.* iv. 77. t. 228. f. *a–e.*

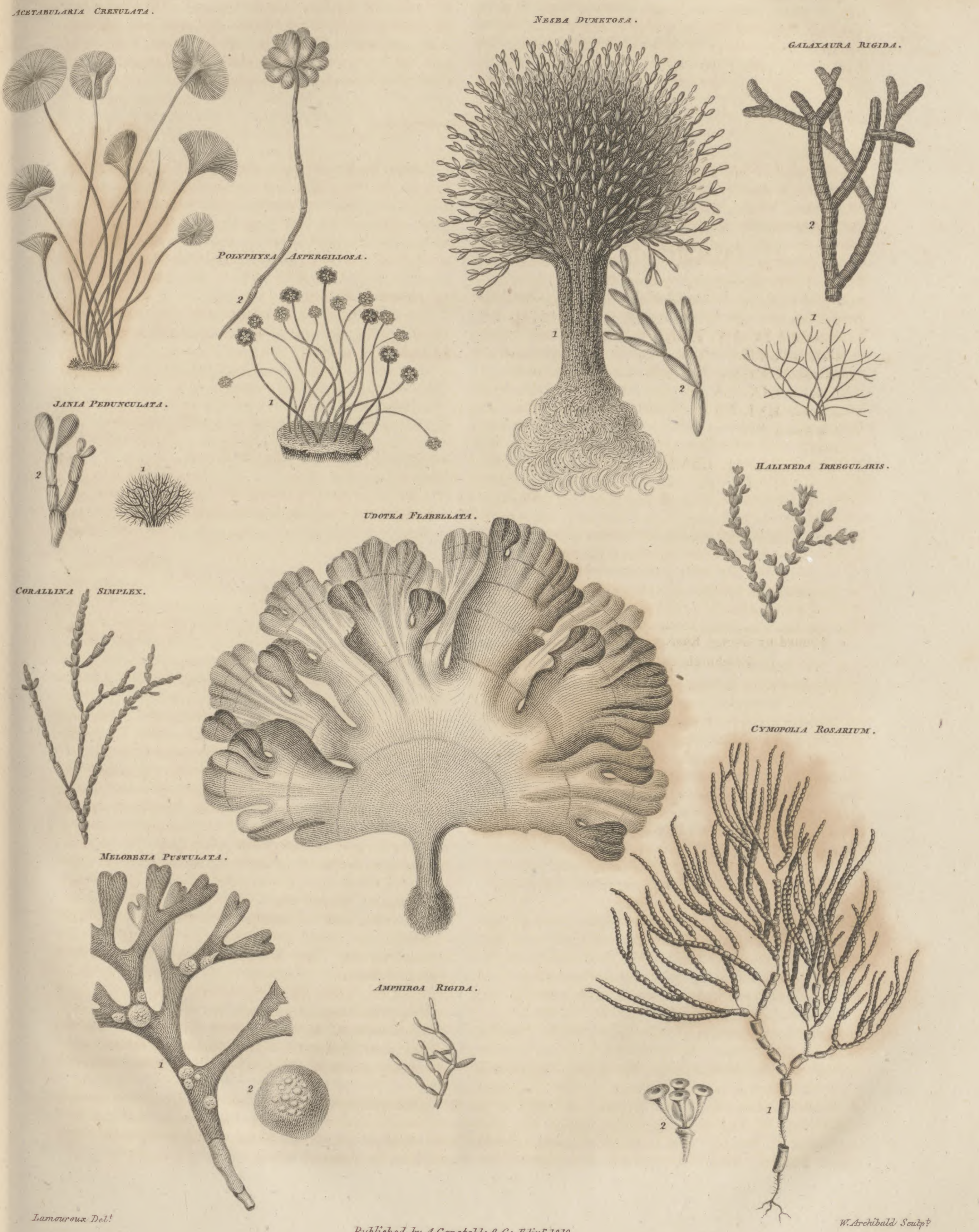
Inhabits the New Holland seas, and is the only species known.

Gen. 3. UDOTEA, *Lamouroux.*

FLABELLARIA, *Lamarck, Cuvier.*

Flabelliform, with an abrupt, distinct, simple stalk; root fibrous; the sides of the flabellum marked with curved, concentric, transverse, regular lines.

This genus inhabits the hotter parts of the American ocean, and is sometimes found in great abundance attached to calcareous rocks, or thrown on the shore after heavy gales of wind.



Lamouroux Del.t W. Archibald Sculp.t

Published by A. Constable & Co. Edin.r 1818.

Corallinidæ.

Sp. 1. *Flabellata.* Plate LXVI. Fig. 1. natural size; 2. portion magnified.

Udotea flabellata. *Lamouroux*, 311.

Flabellaria pavonia. *Lamarck*, *Hist. Nat. des A. s. V.* 343.

The branches of this species are divided into smaller branches; in the other species, *U. conglutinata*, the expansion or branch is undivided.

Gen. 4. NESEA, *Lamouroux.*

PENECILLUS, *Lamarck*, *Cuvier.*

Stalk simple, terminated by a pencil of articulated cylindric dichotomous branches.

The Neseæ are found in the American seas, attached to rocks by their long fibrous roots. When living, their colour is green, which they lose on being dried, and assume a whitish tint.

Sp. 1. *Dumetosa.* Plate LXVI. fig. 1. natural size; 2. branch magnified.

Nesea dumetosa. *Lamouroux*, 259.

Gen. 5. GALAXAURA. *Lamouroux*, *Cuvier.*

DICHOTOMARIA. *Lamarck.**

Fistulous, cylindric, articulate, and dichotomous.

Gmelin and Esper refer the *Galaxauræ* to the *Tabulariæ*; but they are placed amongst the *Corallinæ* by all other authors. Lamarck, who has placed them with his *Polypiers vaginiformes*, very justly observes, that they very much embarrass the zoologist.

Sp. 1. *Rigida.* Plate LXVI. fig. 1. natural size; 2. portion magnified.

Galaxaura rigida. *Lamouroux*, 265.

Inhabits the Indian seas, adhering to marine plants.

Gen. 6. JANIA, *Lamouroux.*

Capillary, dichotomous, articulated: the joints cylindric; the axis corneous; the cortical substance soft.

All authors, excepting Lamouroux, have classed the *Janiæ* with the *Corallinæ*, which may easily be distinguished from each other by the generic characters given by Lamouroux, who first observed the distinctive marks. The greater portion of the species attach themselves to marine plants.

Sp. 1. *Pedunculata.* Plate LXVI. fig. 1. natural size; 2. portion magnified.

Inhabits New Holland seas.

Gen. 7. CORALLINA, *of authors.*

Articulated, branched, trichotomous; axis composed of horny fibres; cortical substance hard.

The presence of calcareous matter in such abundance, as is found in this genus, seems to have been the principal reason which has caused naturalists to refer it to the animal kingdom, since no polype has been observed by those who have had constant opportunities to observe it in the living state. Lamouroux has noticed certain filaments covering a species found on the coast of Calvados, but only in the summer season.

When living, the *Corallinæ* are of a beautiful reddish or purple colour, which they lose after death, and when exposed to the action of the sun and air, assume a great variety of tints. They are found generally on rocky shores, and are generally attached to the rocks, or to the marine plants on the rocks, few being found on the pelagic vegetables.

The most common species on the European coasts is *C. Officinalis*, which was formerly used in medicine as an absorbent, but has lately been rejected from the pharmacopœia. The most characteristic species is,

Corallinidæ || Cork.

Sp. 1. *Simplex*, Plate LXVI.

Corallina simplex. *Lamouroux*, 290,

Which inhabits the American seas.

Gen. 8. CYMOPOLIA. *Lamouroux.*

Dichotomous, articulated; joints moniliform, and separate from one another; axis tubular.

The colour is nearly similar to that of *corallina* in the living and dried state.

Sp. 1. *Rosarium.* Plate LXVI. fig. 1. Natural size. 2. Portion of a joint magnified.

Corallina rosarium. *Gmel. Syst. Nat.* 3842.

Cymopolia rosarium. *Lamouroux*, 294.

Inhabits the Carribean seas.

Gen. 9. AMPHIROA. *Lamouroux.*

Dichotomous or trichotomous, articulated; the joints long and separated from each other by a naked horny substance.

The *Amphiroæ* attach themselves to rocks and other solid bodies, and are not unfrequently found on the shells of those brachyurous malacostraca that inhabit deep water. They are more abundant in warm than in temperate climates, and have never been observed in the polar regions.

Sp. 1. *Rigida.* Plate LXVI.

Amphiroa rigida. *Lamouroux*, 297.

Inhabits the Mediterranean.

Gen. 10. HALIMEDA. *Lamouroux.*

Articulated; joints flabelliform; axis fibrous; cortical substance chalky.

Lamarck has confounded this genus with *Udotea*, from which, it is needless to observe, it is altogether distinct.

Some of the species are parasitical on marine plants, but the greater portion adhere to rocks. They occur in the Mediterranean and American seas.

Sp. 1. *Irregularis.* Plate LXVI.

Halimeda irregularis. *Lamouroux*, 308.

Inhabits the Carribean seas.

Gen. 11. MELOBESIA, *Lamouroux.*

Stony, scale-like, without any stalk.

This scale-like genus is found attached to marine plants, and each species is generally found on the same sort of plant.

Sp. 1. *Pustulosa.* Plate LXVI. fig. 1. Melobesia pustulosa natural size on Chondrus polymorphus; 2. Detached and magnified.

Inhabits the European ocean.

The principal authors who have treated on this group are, Solander and Ellis, *Natural History of Zoophytes*, London, 1786.—Lamarck, *Histoire Naturelle des Animaux sans Vertèbres*, Vol. II. Paris, 1816.—Lamouroux, *Histoire des Polypiers Coralligènes Flexibles.* Caen, 1816.—Esper, *Histoire des Zoophytes.* Nuremberg, 1786.—Ellis, *Essay on the Natural History of Corallines.* London, 1756. (v.)

CORK, a county in Ireland, situated in north latitude 51° 53′ 54″, and in 8° 30″ west longitude from Greenwich, is bounded on the east and south-east by the county of Waterford and St George's Channel, on the north by Limerick and Tipperary, on the west by the county of Kerry, and on the Situation.

Cork. south-west and south by the Atlantic Ocean. This is the largest county in Ireland, being nearly a twelfth of the whole island, and forms part of the province of Munster. It comprehends three dioceses, Cork, Cloyne, and Ross (the two latter were formerly united in one see), but is now divided into two by the junction, in 1586, of Ross, which is very small, with Cork, and 269 parishes, of which 94 belong to the diocese of Cork, 33 to Ross, 137 to Cloyne, and five to the see of Ardfert; extends over 2654⅓ square miles, or 1,698,882 English acres, of which about a fourth is waste and mountainous; and is divided into 16 baronies, besides four districts called the county of the city of Cork, with the liberties of Youghall, Kinsale, and Mallow.

Extent.

Surface. The surface presents great variety; the western part is bold, rocky, and mountainous; on the north and east it is generally rich and fertile, though never flat for any considerable space. The natural scenery is, in several places, uncommonly romantic and sublime, of which Bantry Bay and the waterfall at Hungra-hill (especially after plentiful rains) present very striking instances. The terrific grandeur of the immense surges, swelled by the storm, dashing against the tremendous masses of rock which, stretching out into the Atlantic, form prominent headlands, can with difficulty be conceived by those who have never beheld them. Around Cork harbour the views are singularly beautiful and variegated. Yet the prevailing character of the landscape is wild and naked; in this, as in most other places of Ireland, full grown trees being rare, and plantations recent, and comparatively of small extent. The whole coast is indented by creeks and bays, which are sometimes studded with islets, and commonly sheltered by headlands: Bantry Bay, and the harbours of Cork and Kinsale, are particularly worthy of notice.

Rivers. The most considerable river is the Blackwater, which rises from the mountains on the confines of Kerry, and, after a course of eighty miles, falls into the sea at Youghall. Farther to the south, in the same direction, issues the river Lee, which, flowing eastward, meets the tide at the city of Cork. The Bandon, which has its source in the western mountains, also flows east, and finishes its course at the harbour of Kinsale. The Awbeg deserves to be noticed, from its having been immortalized by Spenser under the poetical name of Mulla. On the banks of this river, at a place called Kilcoleman, above Buttevant, the poet fixed his residence, and, it is said, composed the greater part of his *Fairy Queen.* The rivers of this county flow with rapidity for the most part; a circumstance unfavourable to their being rendered navigable, but presenting many eligible situations for the erection of machinery.

Climate. The winds blow here from the south to the north-west more than three-fourths of the year; for eleven years, ending with 1748, the medium quantity of rain at Cork was 38 inches; the barometer ranges from 28.6 to 30; and the mean temperature on the south coast, near the city of Cork, in 1788, was 51° 2′, and in different parts of the city itself, from 52° 5′ to 53° 5′. It is a very general opinion here, that a change for the worse in the climate has taken place within the last 40 years.

Fossils. The most useful fossils are *limestone*, which abounds to the north of the river Blackwater, and in a tract which begins to the westward of Cork, and, running from thence eastward, terminates at Youghall Bay; *marble*, of which ten different kinds are enumerated by Dr Smith, all of them variegated, no large block of a single colour having yet been found; and *slates*, near Kinsale, on the Bandon river, and at Cloghnakilty. Coal has been discovered in the barony of Duhallow, in the north-west quarter of the county, but is not wrought to any great extent, owing to the badness of the roads, and its being so combined with sulphur as to be unfit for domestic use. *Iron* abounds, and *lead* has been found in small veins; neither of them are wrought at present.

Rural Economy. The rural economy of this district does not seem to differ materially from that of the other counties of Ireland similar to it in surface and climate. There is the same minute division of tillage lands cultivated by the spade in preference to the plough; the usual dependence on potatoes, as the common and almost exclusive article of food; with miserable cabins, crowded with filth, poverty, and indolence. Estates are generally large; tillage farms very small, seldom above 30 acres; and, when they are larger, often held in partnership, and the shares of each further diminished by the common practice of dividing the paternal possession among the sons. The leases used to be for thirty-one years, or three lives; but of late the term has been reduced to twenty-one years, or one life; and the farms, instead of being let out to middlemen, who used to relet the land in small portions to occupiers on short leases, or at will, are now held in most cases by the occupier from the proprietor himself. The crops are potatoes, in favourable situations succeeded by wheat; and oats, for one or more years, sometimes barley, follow the wheat. Flax is cultivated in many small patches, which yield an aggregate produce of about 1200 tons. Hemp very rarely. Turnips and clovers are seldom to be seen on tenanted lands. Sea-sand, sea-weed, and lime, form a useful addition to the stable and farm yard manure, which is, however, in many cases, allowed to be washed away by rains, and greatly reduced in value by careless management. Paring and burning is practised in every part of the county, as an established mode of preparation for the first crop in the course. The implements of husbandry are generally bad—the common Irish plough and harrows, seldom furnished with iron tines, drawn by horses or mules, and in a few instances by oxen; wheel carriages have become pretty common of late. A considerable number of dairies are kept in the vicinity of the city of Cork, where the produce, in the shape of butter and skimmed milk, finds a ready market. In general, the cows, which are chiefly of the half Holderness breed, are let out to a dairyman at a certain rate for each, by the year; yet many farmers conduct the business of the dairy themselves. The average number of cows in a dairy may be from 30 to 40. A few sheep are kept on every farm, commonly in fetters, and upon the most worthless pasture. Proprietors have introduced stranger breeds, and find them to answer; but sheep can never become an object of importance in a district where

Cork.

farms are so small. The rental of the county comprises a great variety of rates; the mountainous and boggy tracts being valued so low as 6d. *per* acre, and the land near the principal towns as high as L. 4. Townsend thinks that 20s. *per* English acre may be the average rent of the whole, which is probably much above the truth.

Rental.

Tithes.

Tithes, of which no inconsiderable part are lay property, are generally paid by a composition with the farmers. The usual mode is to have them valued before harvest, and to appoint days of meeting with the parishioners for the purpose of letting them. Small tithes, or (as they are commonly called) small dues, viz. those of wool, lambs, &c. are for the most part relinquished. Flax, cultivated to some extent only in the south-west quarter, is commonly rated at 4s. *per* peck of the seed sown. The rates of valuation vary, according to circumstances and situation, from 6s. to 14s. *per* acre for potatoes; from 6s. to 12s. for wheat and barley; and from 3s. to 6s. for hay and oats. The revenue of the Bishop of Cloyne is derived from land and tithes; that of Cork almost entirely from land; and the amount of both fluctuate accordingly. The patronage of these sees is very considerable, nearly all the livings being in the gift of the bishops; and some of these livings, especially in the diocese of Cloyne, are of great value, many of the benefices being composed of the union of contiguous parishes. A great number of the parishes are without churches, and many more without glebe houses.

Manufactures.

The principal manufactures are sail-cloth, duck, canvass, and drilling; osnaburgs for Negro clothing; coarse woollens; spirits at several large distilleries in Cork; and gunpowder in the neighbourhood of the same city,—the only manufactory of that article in Ireland, and it belongs to government.

Towns.

The chief towns are Cork, Kinsale, Youghall, Bandon, Skibbereen, Cloghnakilty, Mallow, and Fermoy. Of these Cork, the second city in the island, is by far the most considerable. The old city stood upon an island formed by the river Lee, which divides into two branches above the town, and unites again a little below it, embracing a considerable extent of low ground, subject to frequent inundations from high tides and floods. Besides the two main channels, several small branches of the river intersected this marsh, flowing through many of the streets, and giving it a striking resemblance to some of the Dutch towns. These have been arched over. The main channels are crossed by several bridges; and the principal part of the town is now on the south bank of the river. On the north-east side of the city stand the barracks, capable of containing four regiments of infantry and a thousand horse. The streets of the old town are commonly very narrow and dirty; in some of the lanes two persons cannot walk abreast. Yet these miserable alleys, the receptacles of every kind of filth, are crowded with inhabitants. On the west of the town there is a very fine walk of about a mile, called the Mardyke Walk, considerably raised above the level of the adjoining fields, and planted on each side with elms. The corporation, under a charter of Charles I., consists of a mayor, two sheriffs, a recorder, several aldermen, and an unlimited number of freemen. Cork contains all those establishments for the diseased, the poor, and the guilty, and for religion, education, and amusement, which are usually found in large cities, with foundling hospitals both for Protestants and Catholics. The *Cork Institution* for the application of science to the common purposes of life, has been incorporated by charter; and under its auspices, lectures are delivered on Chemistry, Botany, and Agriculture. Cork harbour, about eight miles below the town, is the principal naval station in Ireland, and is also a place of rendezvous for fleets bound to the West Indies. Vessels of 120 tons go up to the city, but larger ships lie at *Passage*, a few miles lower down. Between the city and the sea there are several islands, on one of which, called the Great Island, is the town of Cove. The harbour has been fortified at a great expence, and is capable of containing an immense navy. Cork carries on a very extensive trade, particularly in provisions, large quantities of which are required for the ships of war that frequent the harbour, and by the West India fleets, which sometimes remain here several weeks either wind-bound or waiting for convoy. All the linens and woollen goods from the southern districts, intended for a foreign market, are shipped here, and large quantities of spirits are sent from the distilleries to England. About 10,000 oxen, 8000 cows, and 50,000 hogs, are said to have been slaughtered here annually, but the numbers are liable to great fluctuation. In 1807 only 3600 head of cattle were slaughtered. In the provision trade Dublin seems to be gaining both on Cork and Limerick. Corn, butter, tallow, and hides, are exported to a considerable amount.

Cork Harbour.

Population.

According to Beaufort, the population of this county, in 1792, was 416,000, in which the Catholics were to the Protestants in the city of Cork as $4\frac{1}{2}$ to one, and in the rest of the county as 12 to one. Newenham estimates the population, in 1811, at 675,364, and, taking the same proportion of 12 to one for the county, gives the Catholic population of the towns as six to one. The Irish language is used almost exclusively by the lower orders; in some of the best cultivated districts few of the people can speak any other. Cork sends eight members to the House of Commons, of which two are for the county, two for the city, and one for each of the boroughs of Youghall, Bandon Bridge, Kinsale, and Mallow. See Smith's *Natural and Civil History of Cork*.—Wakefield's *Statistical and Political Account of Ireland*.—Townsend's *Statistical Survey of Cork*, and Mason's *Parochial Survey of Ireland*. (A.)

Representation.

CORN LAWS AND TRADE.

Historical Sketch of the Corn Laws.

History of the Corn Laws.

It has been the fault of all governments, in every age of the world, to interfere too much with the affairs of their subjects. The idea that certain branches of commerce were particularly advantageous to society, though they might be ruinous to an individual who should attempt to carry them on; and that other branches, which might be profitable to individuals, were not unfrequently inconsistent with the general advantage, has been almost universally prevalent. On a first view, this opinion, though essentially erroneous, seems sufficiently plausible. Many of the pursuits of individuals apparently conduce very little, and may sometimes even seem hostile, to the interest of the whole; and hence we are naturally enough led to infer, that the general advantage would be best consulted by prohibiting such pursuits or employments. In nothing, however, has this notion of the propriety of restricting and directing the operations of industry and the investment of capital been so apparent, as in the regulations framed respecting the trade in corn. This, indeed, is only what might have been expected. To secure an adequate supply of food, and to avoid the pressure of famine and scarcity, must always be an object of the first importance with the legislators of every country; and while the efficacy of the restrictive system is unquestioned, it is here it will be chiefly called into action.

But, when legislators abandon the principle of free competition, and imagine they can factitiously give a more advantageous direction to the national industry, their accustomed habits, and their situation in life, will have a very powerful effect in determining the nature of the regulations they adopt. Agriculturists raise corn for *sale* as well as for their domestic consumption; and as it is natural that landlords and farmers should endeavour to obtain a high price for their produce, where their voice predominates in the legislature of a country placed under the restrictive system, it is but reasonable to presume, that the regulations respecting the corn trade will be framed rather with a design to enhance than to lower its price. Whether they have had that effect is an entirely different, and often a very delicate inquiry; but unless there is pretty explicit evidence to the contrary, it is not easy to imagine, that agriculturists, or those supported by agriculture, would give their consent to any law which they conceived had for its object to lower the exchangeable value of agricultural produce. On the other hand, where the legislature of a country is either principally composed of merchants, manufacturers, or of capitalists depending on the profits of stock, as was formerly the case in Holland; or, where the legislature is chiefly influenced by them, it is nearly certain it will not intentionally adopt any measure which may have for its object to raise the value of the produce of the farmer. When the value of agricultural produce is low, a manufacturer will be able to exchange his commodities for a comparatively larger quantity than he could possibly do after its value had been enhanced by legislative enactments. How then is it to be expected he should ever consent to any measure, if he judged it had the least tendency to raise prices?

History of the Corn Laws.

Throughout the principal Continental States, the regulations affecting the corn trade have been framed chiefly with a view to keep down the price of corn. This fact, however, is perfectly consistent with the principles we have just laid down. After the feudal system had lost its energy, and after the power of the great barons had been weakened by the rise of cities, and the consolidation of the royal authority, monarchs were enabled to take such measures as appeared best calculated to benefit the lower classes of their subjects, which it was then their object to exalt, by reducing the exchangeable value of raw produce. Of these measures, none seems more natural, nor better calculated to effect its object, than the imposing of restrictions on exportation. If a nation raises more corn than is required for its home consumption, the first consequence of a prohibition against its export will undoubtedly be to lower its value. It is certain, indeed, that this effect will very soon cease; but, in early ages, men seldom attend to prospective considerations, and it is not a very easy matter, even now, to convince the bulk of mankind, that the granting liberty to send abroad the necessaries of life really lowers their price in the home market. To be able satisfactorily to demonstrate this principle, requires a considerable acquaintance with political economy,—a science altogether unknown, when the laws regulating the corn trade were first framed in the European commonwealth. With a view still farther to reduce the price of corn, a perfect freedom of importation was very generally allowed; and, in periods of scarcity, bounties, or premiums, over and above the market price, were sometimes given by the state to the importer.

In this country, an opposite course has been pursued. The progress of society and government has been such, that the Lords and Commons, the first depending entirely, and the latter principally, on agriculture, have attained great power and influence; and we cannot be surprised at their having generally exerted it to increase, not to lower, the price of corn.

Restrictions on exportation, without being in the least advantageous to the consumers of raw produce, are eminently hurtful to agriculturists. While they exist, no market can be found for that excess of produce which an agricultural country generally has to dispose of in favourable seasons. Farmers are not, therefore, stimulated to exertion, because, in a coun-

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try thus situated, a luxuriant crop, by its causing a great fall of price, is nearly as prejudicial to them as a scarcity; which, indeed, by its lessening the quantity sown next year, it seldom fails to induce. In most countries, however, these very simple considerations have been overlooked, and the export of corn, unless in years of extreme plenty, has been forbidden under the severest penalties. In the reigns immediately succeeding the conquest, this was the case in England; but, in 1436, in the reign of Henry VI. an act was passed permitting export without licence, whenever the price of wheat did not exceed 6s. 8d. (equal in amount of pure silver to 12s. 10¾d. present money) *per* quarter, and barley 3s. 4d. In this act it is stated, that the previous regulations had obliged farmers to sell their corn at low prices, to the great prejudice of the whole kingdom. But, in addition to the reason here assigned for this important measure, we may observe, that, for a considerable time posterior to the conquest, rents were paid in kind, and the high or low price of raw produce could not, therefore, be reckoned a matter of so much importance to landlords, as it became after money rents were generally introduced. In Henry I.'s time, the rents of the Crown lands were paid in corn and other consumable commodities, and were only converted into pecuniary payments, in consequence of the great complaints made by the tenants of the inconveniences they suffered in bringing necessaries for the king's household from distant parts of the kingdom. (Eden's *Inquiry into the State of the Poor*, Vol. I. p. 55.) The same causes would doubtless affect, though in a less degree, the tenants of the great barons; and, when once money rents had been introduced, it was for the advantage of the proprietors that the obstacles tending to keep the price of corn from rising should be removed. A more favourable opportunity could not have been found to break down these restraints. Henry, weak and irresolute, with a disputed title to the throne, and a powerful competitor, could not, had he been so disposed, have made any effectual opposition to the change of the system on which the corn trade had previously been conducted.

Statute of 1436, permitting Exportation.

At the time when this act was passed, the prices of corn were exposed to fluctuations of which we can now form a very inadequate conception; and hence it is not easy to determine whether the exportation price of 6s. 8d. was above or below the medium price. While the trade of corn merchants and corn factors was unknown, or while it laboured under degrading restrictions, very little providence was exercised in the distribution of the crops, and the superfluous produce of one year scarcely ever compensated for a deficiency in the crop of the next. "Purchasers," says Sir F. M. Eden, "who only looked to their immediate wants, having corn cheap, were naturally wasteful and improvident in the consumption; the price, therefore, almost invariably rose as the year advanced, and was frequently at an enormous height just before harvest; and, before a fresh supply could be obtained, the stock of the preceding year was often entirely exhausted." (*Inquiry into the State of the Poor*, Vol. I. p. 18.) Of this Sir Frederick has collected many instances; and he conjectures, seemingly with great probability, that the enthusiastic joy with which the rustic feast of harvest-home was anciently celebrated, arose chiefly from the almost constant fall that then took place in the price of corn.

That the act of 1436 contributed to the advantage of the English agriculturists cannot be doubted; and having experienced the benefit of legislative interference in one instance, they were not slow in again having recourse to it. Not satisfied with this liberty of exporting, in the following reign (1463), they procured the enactment of a law prohibiting the *importation* of corn from abroad, until the home price exceeded the price at which exportation ceased. If the uncertain and fluctuating policy of the times had permitted the proper execution of these laws, the restrictive system would thus early have been perfected, and, with the exception of the *bounty*, all the refinements of modern policy would have been in full operation. In practice, however, they were almost inoperative, and a long period elapsed ere the agriculturists succeeded in obtaining a real monopoly of the home market. (Dirom's *Inquiry*, p. 34.)

Statute of 1463, prohibiting Importation.

Until the reign of Elizabeth, these acts nominally regulated the prices at which the export and import of corn might take place. In that period, however, the coin had not only been greatly degraded, but in the latter part of the 15th and in the 16th centuries, the value of silver, owing to the discovery of the American mines, was rapidly falling throughout Europe. The consequent rise of prices, as it could not, in a nearly stationary state of society, and when capital was but slowly accumulating, be speedily followed by a corresponding rise of wages, must necessarily have been productive of much general distress. But neither the government nor the people seem to have been at all aware of this being the real cause of the rise of money prices, and of the extraordinary increase of pauperism in this interval.* It was not yet known that silver may fall in value,

* In 1436 the pound Sterling contained as much pure silver as is now contained in L. 1, 18s. 9d. In 1464 the value of the pound Sterling was reduced to L.1, 11s. present money, at which sum it remained stationary until 1527, when it was reduced to L. 1, 7s. 6¾d. present money. In 1543 the previous value of the coin was again reduced about one-seventh part, or to L. 1, 3s. 3¼d. present money. In the ten years subsequent to this era, the process of degradation advanced with unparalleled rapidity; the weight of the coin was not only diminished, but the standard purity of the metal itself was debased, so that in 1551 the pound Sterling only contained as much silver as is now contained in 4s. 7¾d. In 1552, the last year of the reign of Edward VI. the standard was again restored to its former purity; but the weight of the coin, and consequently the quantity of pure silver which it contained, was at the same time reduced about *one-seventh* below its weight in 1543, and hence the value of a pound Sterling in 1552 corresponded to L.1, 0s. 6¾d.

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and that this fall must always be attended by a proportionate rise in the money price of the commodities for which it is exchanged. Instead, therefore, of ascribing the enhancement of prices to the degradation of the coin, or to the greater plenty of gold and silver, it was universally affirmed to be owing to the *decay of tillage*, and to the improper practices of corn-merchants; and many now obsolete statutes for the improvement of tillage, and the laws against engrossing, forestalling, &c. owe their origin to the absurd attempts then made to lower the price of corn.

That the complaints respecting the decay of tillage were very ill-founded, appears pretty evident. The great foreign demand for English wool, the export of which was not then prohibited, had caused the consolidation of some small farms and the more general introduction of enclosures. But this fact, so far from being any proof of this decay, affords satisfactory evidence of the accumulation of capital, and shows that some improvement had already taken place in agriculture.* The increase in the size of farms is, no doubt, always disagreeable to the lower classes; and being then attended with a great rise of prices, raised the popular indignation to such a pitch, that, in the reign of Edward VI. the greater part of the inclosures were violently demolished. As might have been forcseen, the statutes directing the extension of tillage effected nothing; unfortunately, however, the statutes against engrossing were not quite so inefficient.

Statutes against Forestalling and Engrossing.

By the statute 5th and 6th of Edward VI. cap. 14, it was enacted, That whoever should buy any corn or grain, with intent to sell it again, should be reputed an unlawful engrosser, and should, for the first fault, suffer two months imprisonment, and forfeit the value of the corn; for the second suffer six months imprisonment, and forfeit double the value; and for the third, be set in the pillory, suffer imprisonment during the King's pleasure, and forfeit all his goods and chattels. And by the same law no person could transport corn from one part to another, without a licence, ascertaining his qualifications as a man of probity and fair dealing. Neither could corn be purchased to be laid up in granaries for home sale, until the quarter of wheat was at or under 6s. 8d. and oats at 2s. money of the time. By the same statute, the authority of three Justices of the Peace was necessary in order to grant a licence; and even this restraint, not being thought sufficient, by a statute of Elizabeth, the privilege of granting it was confined to the quarter-sessions.

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That very little opposition should have been made by the landed interest to the laws restricting the freedom of the internal corn trade, does not appear very surprising. Before the principles of trade were properly understood, it was extremely natural for landlords and farmers to conclude, that they would be able to sell their produce directly to the consumers, on fully more advantageous terms than if they transacted with them through the medium of a third party. Forgetting that these profits were but a fair remuneration for the capital which had been invested in the most important of all employments, that of distributing the supply of food equally throughout the year, and according to the effective demand, the farmers considered the whole of the profits of the corn-merchants to have been acquired from the consumers at their expence; and of course could not feel any great repugnance to the virtual annihilation of the trade of the dealer.

But, as society improved, and as the principles of commerce were better understood, the bad effects of these laws became apparent. The statute of 1548 was considerably modified in 1624, and at last, by the 15th of Charles II. cap. 7, the engrossing or buying of corn, in order to sell it again, as long as

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present money. Since that period the standard has undergone almost no variation, either as to weight or purity.

It therefore appears, that between 1527 and 1552, the value of the pound Sterling was reduced from L. 1, 7s. 6¾d. to L. 1, 0s. 6¾d. or about *one-fourth* part; and this degradation of the value of the coin, accompanied as it was by an extraordinary fall in the value of the precious metals themselves, leaves us at no loss to account for the distress with which the people of England were then assailed, and for the universal complaints of a rise of prices. The dissolution of the monasteries by Henry VIII. in 1536 and 1538 has commonly been considered as the cause of the institution of a legal provision for the support of the poor in England; but that this was really a consequence of the misery of the lower classes, caused by a degradation and fall in the value of money, seems abundantly certain. " The principal real grievance at this time," says Mr John Smith (*Memoirs of Wool*, 8vo ed. Vol. I. p. 88), when adverting to some riots and complaints caused by the high prices in 1550, " of the poorer manufacturers, they do not appear to have been sensible of, and historians have since overlooked it, was the *state of the coin*. The debasement of the coin, which was now of several years standing, had undoubtedly given a nominal advance to all things vendible; and, though perhaps to wages too, yet probably nothing near in proportion to the difference of the coin. And, as the money in which they were paid, not containing as much silver as it did before, would not purchase the same quantity of the necessaries of life it was wont to do; that, in course, must have bore hard upon the lower sort of people especially, who had every thing to buy and nothing to sell, except their labour." This idea has been borrowed, and illustrated in an article of considerable merit, published in the 22d volume of the *Edinburgh Review*.

* In 1553 an act was passed, restraining the number of sheep to be kept in one flock to 2000. It is mentioned in that act, that some proprietors had then flocks of 24,000 sheep. Anderson states, that in 1551 no fewer than 60 ships sailed from Southampton for the Netherlands, loaded with wool. *History of Commerce*, Vol. II. p. 89.

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the price of wheat did not exceed 48s. the quarter, was declared lawful to all persons, not being forestallers, that is, not selling again in the same market within three months; an act, as Dr Smith has justly observed, which, with all its imperfections, has contributed more, both to the plentiful supply of the home market, and to the increase of tillage, than any other law in the statute book.

The act of Henry VI. regulating the export prices of corn was again renewed, but without any variation in the rates, in the reign of Philip and Mary. As the coin, however, had, in the interim, been greatly degraded, of course exportation could not now take place, until the price had really fallen much lower than the price of 1436. This act, like that against engrossing, was no doubt framed with a view of reducing the rising money price of corn, and of quieting the discontent then prevalent among the labouring classes; although, by shackling and discouraging cultivation, its real effects must have been extremely different.

Statutes of 1562 and 1570.

In 1562 the prices at which exportation might take place, were extended to 10s. *per* quarter for wheat, and 6s. 8d. for barley and malt. This scale, however, was soon after abandoned; and in 1570 it was enacted, That corn might be exported from particular districts; wheat paying a duty of 1s. and other grain of 8d. *per* quarter, whenever no prohibition to the contrary had been issued by government: And that the Lord Presidents, and councils for shires, and the Justices of Assize, at their different sessions, should consult with the respectable inhabitants of the counties, and determine whether any exportation could with propriety be allowed.

The curious provisions of this act, whereby corn might be exported from one part of the country, at the same time that its exportation was prohibited in another, arose from the extreme inequality of the then prices. At this era roads were scarcely formed; and as there hardly existed any communication between distant parts of the kingdom, the prices in the different counties bore no proportion to each other, or to the price in London. England was then in the same situation as Spain in the present day. A particular province might be afflicted with scarcity, without being able to derive any assistance from the superfluous produce of its neighbours. But the complex nature of the regulations prevented their being properly executed; and they were again superseded by a fresh law (35th Eliz. c. 7), permitting export, on paying a duty of 2s. for wheat, and 1s. 4d. on all other species of corn, whenever the price of wheat did not exceed 20s. *per* quarter, and barley and malt 12s. This act did considerable service to agriculture, by repealing several absurd statutes for the promoting of tillage, and against the enlargement of farms.

Origin of the Poor Laws.

It deserves to be remarked, that the check given to cultivation by the injudicious imposition of heavy duties on the export of corn, and still more, the rapid depreciation of the value of money in the reign of Elizabeth, caused an astonishing rise in the price of commodities. A contemporary author, quoted by Mr Hume, estimates this rise in the 20 or 30 years previous to 1581, at no less than 50 *per cent.*; but as wages could not increase in proportion, pauperism became very general; and this circumstance, combined with the excessively high prices of 1596, 1597, and 1598, occasioned the enactment of the famous statute of 1601, which has served as a basis to the whole of the present English system for supporting and managing the poor. *

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* The contemporary author quoted by Mr Hume (*Hist. of England*, Vol. V. p. 485), and by Sir F. M. Eden (*State of the Poor*, Vol. I. p. 119), says, that, in 1581, it required L. 200 to keep as good a house as might have been kept 16 years before for 200 merks, or L. 133, 6s. 8d.—" Cannot you remember," says he, " that within these 30 years I could, in this town, buy the best pig or goose I could lay my hands on for 4d., which now costeth 12d.; a good capon for 3d. or 4d.; a chicken for a 1d.; a hen for 2d., &c. Now a payre of shooes costs 12d.; yet in my time I have bought a better for 6d."—Latimer, in his Sermons, ascribes this increase of price to landlords raising their rents. " Notwithstanding," says he, " God doth send us plentifully the fruits of the earth mercifully according to our desertes, these rich men causeth such dearth, that poore men, which live of their labour, cannot with the sweat of their face have a living, all kinde of victuals is so dear."—A variety of passages to the same import may be found in other contemporary authors quoted by Sir F. M. Eden, and by Mr Smith in his *Memoirs of Wool*.

This extraordinary advance of prices, caused partly by the degradation of the coin, but more by the fall of the exchangeable value of the precious metals themselves, as it must have very far exceeded the rate at which capital, and consequently the demand for labour, was then increasing, would, even on the supposition that wages had been left to find their own level, and to be adjusted on the principles of fair competition, have been attended with a very great deterioration in the circumstances of the labouring classes. But positive enactments were framed to prevent their increase; and while the money price of all sorts of commodities was advancing with unprecedented rapidity, wages were violently kept down to very near their former level.

By the statute 11th Henry VII. c. 22, regulating the wages of labour, a common labourer was allowed 4d. *per diem*, from Easter to Michaelmas; and taking the average prices of wheat, rye, and barley at that period at 6s. 8d. 4s. and 3s. *per* quarter, respectively, it will follow that a labourer who had 4d. a day, could earn a quarter of wheat by twenty days labour, a quarter of rye by twelve days labour, and a quarter of barley by nine days labour.

But in the latter part of the reign of Queen Elizabeth, the labourer's situation was very different. The prices of corn may be supposed to have nearly corresponded with the rates at which exportation was al-

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No alteration was made in the amount of the duties payable on the export of corn, during the pacific reign of James I.; but the prices at which exportation might take place, were, after some trifling alteration in 1604, fixed in 1623 at the high rate of 32s. the quarter for wheat, and 16s. the quarter for malt and barley. In this and the preceding reigns, and for a considerable time afterwards, the importation of corn continued unrestricted; and notwithstanding the improvement of agriculture, the nation was then partially dependent for supplies of food on the trade with the Baltic and other countries.

During the agitations of the civil wars, the people of England, intensely occupied in endeavouring to throw off, or at least to restrict and modify the royal authority, paid no regard to the corn trade. But this inattention does not seem to have been attended with any bad effects. The high prices of that turbulent period, if they were not altogether caused by a fall in the value of the coin, which, previous to the recoinage under Cromwell, had been very much clipped and debased, were most probably owing to the interruptions then thrown in the way of agricultural labour.

Statute of 1660, regulating Exportation.

On the restoration of Charles II. in 1660, an act was passed, permitting the export of corn on the same terms with other commodities on which duties were payable, whenever the price of wheat did not exceed 40s. *per* quarter, barley and malt 20s. and oats 16s. But as by this law a duty of 20s. was exigible from every quarter of wheat exported, and from other grain in proportion, it really amounted to a prohibition; and neither the agriculturists nor the revenue derived any advantage from the extent to which exportation was permitted, although both must have been somewhat benefited by the high duties it imposed on importation.

Mr Dirom's opinion that the prohibitory duties on *exportation* were the chief causes of the high prices of *this and the two following* seasons, seems

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lowed by statute 35th Eliz. c. 7, that is, wheat probably averaged 20s. a quarter, rye 13s. 4d. and barley 12s. It appears, however, from the determination of the Justices of the East Riding of Yorkshire, in the same year, that the wages of a common labourer, without meat or drink, were limited to *five* pence a day from the 1st March to the Feast of all Saints. Consequently, a common labourer could not, in the latter part of the reign of Queen Elizabeth, earn a quarter of wheat by less than 48 days labour, a quarter of rye in less than 32 days, nor a quarter of barley in less than 28⅘ days. If barley was his common sustenance, he could have earned *three* times as much in 1495 as in 1593; of rye 2⅖ as much; and of wheat 2⅖. As far, therefore, as the necessaries of life were concerned, the situation of the labourer was not *one half* so advantageous in 1593 as it had been in 1495. (*Edinburgh Review*, Vol. XXII. p. 195.)

This extraordinary rise in the price of provisions, attended as it was by no proportionable rise in the price of labour, was the real cause of the instituting of poor-rates. In the long interval between 1379 and 1530, it does not appear that any statute was passed which had a direct reference to the maintenance of vagrants or beggars. At the latter era, however, when the prices of all sorts of commodities began suddenly to rise, pauperism became very prevalent, and engaged a considerable portion of the attention of the legislature.

The following extract from Dr Burn's *Justice of Peace* (Vol. III. p. 608), shows, in a very distinct manner, the various steps by which the compulsory maintenance was established in England: "By 22d Henry VIII. c. 12, the Justices were to distribute themselves into several *divisions;* within which divisions respectively they might *license* persons to beg. By 27th Henry VIII. c. 25, the several hundreds, towns corporate, parishes, or hamlets, were required to *sustain* the poor with such *charitable voluntary alms*, as that none of them might, of necessity, be compelled to go openly in begging, on pain that every person making default should forfeit 20s. a month. And the church-wardens, or other substantial inhabitants, were to make collections for them with boxes on Sundays, and otherwise by their discretions. And the minister was to take all opportunities to stir up and exhort the people to be liberal and bountiful. By the 1st Edward VI. c. 3, houses were to be provided for them by the devotion of good people, and *materials* to set them at work; and the minister, after the gospel every Sunday, was specially to exhort the parishioners to a liberal contribution. By the 5th and 6th Edward VI. c. 2, the collectors of the poor, on a certain Sunday in every year, immediately after divine service, were *to take down in writing* what every person was willing to give weekly, for the ensuing year; and if any should be obstinate and refuse to give, the minister was gently to exhort him; if he still refused, the minister was to certify such refusal to the bishop of the diocese, and the bishop was to send for him, to induce and persuade him by charitable ways and means, and so according to his discretion *to take order for the reformation thereof.* By the 5th Elizabeth, c. 3, if he stood out against the bishop's exhortation, the bishop was to certify the same to the Justices in sessions, and bind him over to appear there; and the Justices at the said sessions were again gently to move and persuade him; and, finally, if he would not be persuaded, then they were to *assess* him in what they thought reasonable towards the relief of the poor; and, in case of refusal, were to commit him till paid. By 14th Elizabeth, c. 5, power was given to the Justices to lay a *general assessment*, and this hath continued ever since; for the statute of the 43d Elizabeth, c. 2, is only a re-enacting of former provisions, with some additional alterations."

In a tract published in 1611, the author dwells with great earnestness on the extreme dearth of victuals. They were grown more dear in price, he affirms, in the six years foregoing, than in the twenty years before.—See *Memoirs of Wool*, Vol. I. p. 128. The fall in the value of gold and silver, caused by the discovery of the American mines, seems to have ceased about 1630 or 1640.

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entirely destitute of foundation. The law against exportation could not certainly *raise* the prices of the year in which it was framed, and this high price, as far as it was not caused by a deficiency in the crop, or by any fluctuation in the value of the coin, was unquestionably owing, not to the duties on exportation, but to the exorbitancy of those on *importation*, which had really secured a monopoly of the home market to the agriculturists.

This view of the matter appears to have been the same with that which had occurred to Parliament; and in 1663 the high duties on importation were again taken off, and an *ad valorem* duty of 9 *per cent.* imposed in their stead. At the same time, the exportation price of wheat was extended to 48s. *per* quarter, chargeable with a duty of 5s. 4d. and other grain in proportion.

Statute of 1670.

This act, however, by permitting the import of foreign grain on paying a moderate duty, not being reckoned sufficiently advantageous to the landholders, a more decided step was subsequently taken, and in 1670 exportation prices were extended to 53s. 4d. *per* quarter for wheat, and other grain in proportion, while import duties, amounting to a complete prohibition, were imposed on foreign wheat till the home price reached 53s. 4d. and between that price and 80s. a duty of 8s. was exigible. But this law, though extremely favourable to the agriculturists, by whom indeed it had been framed, did not perfectly correspond with their wishes. The necessities of the Crown had still caused the continuance of the impolitic duties on exportation, and the prohibition of importation was rendered to a certain extent nugatory, by the want of any proper and settled method for ascertaining prices. Groundless complaints of the decay of agriculture, and of the evils of foreign competition, were therefore continued, and gave occasion to the act of 1685, designed more effectually to check the import of corn from abroad, by securing correct returns of the prices.

Bounty Act.

We have now reached a period no less memorable in the economical, than in the political history of Great Britain. The era of the granting of a BOUNTY on the export of corn, and of the establishment of our civil liberties, is the same. The Prince of Orange could not, had he been so inclined, have opposed any obstacles to the wishes of the landed interest, who then constituted the immense majority of Parliament, on this particular subject. Whether or not the court really approved of this measure, cannot now be ascertained; but whatever might have been William's private sentiments, it was necessary for him to give way to the inclinations of the men who had so lately raised him to a throne, and on whose assistance he was chiefly to depend, in prosecuting his war against France. The *bounty* payable under the act 1st William and Mary, c. 12, amounted to 5s. for every quarter of wheat exported, while the price continued at or below 48s.; 2s. 6d. for every quarter of barley or malt, while their price did not exceed 24s.; and 3s. 6d. for every quarter of rye, when the price did not exceed 32s.

A still more essential advantage was shortly after conferred on agriculture, by the act 11th and 12th William III. cap. 20, which repealed all the previous duties on corn exported, and prevented the operation of the bounty from being in the slightest degree counteracted.

No alteration having been made in the prices and duties regulating the importation of foreign corn, as fixed by the act of 1670; and the duties being rigorously exacted, the act repealing the duties on exportation completed the restrictive system. Every part of this complex machine was now in operation; and while no foreigner was allowed to contend with our own home growers, the liberality of the state enabled them to contend with foreigners, even when the price of corn in Great Britain was considerably higher than its price abroad!

Scottish Corn Laws.

The policy adopted in Scotland, respecting the trade in corn, had been nearly the same with that of England. Previous to 1663, the importation of corn into this kingdom was permitted without limitation or duties (Dirom, p. 61); but in that year it was loaded with an *ad valorem* duty of about 40 *per cent.*; while its free export was allowed, on payment of a trifling duty, until the prices exceeded those mentioned below.* This duty was afterwards relinquished, and a bounty granted by the statute William, Par. 1. c. 32. At length, by the Treaty of Union, the corn laws of both kingdoms were incorporated, and it was settled, that "the allowances, encouragements, and drawbacks, prohibitions, restrictions, and regulations of trade, and the customs and duties on import and export, settled in England when the union commences, shall, from and after the union, take place throughout the whole United Kingdom." Oats not having been mentioned in the English statute granting the bounty, it was here declared, that whenever oats did not exceed the price of 15s. sterling *per* quarter, there should be paid a bounty of 2s. 6d. for every quarter of oatmeal imported.

Effects of the Bounty Act.

Whatever may have been the ultimate consequences of the bounty act, there can be no doubt it was framed with a view to enhance the value of corn. In the preamble to this celebrated statute, it is stated, "that the exportation of corn and grain into foreign parts, *when the price thereof is at a LOW rate in this kingdom*, hath been a great advantage, not only to the owners of land, but to the trade of this kingdom in general." It would, indeed, be extremely absurd to suppose that the landed interest should have unanimously and earnestly urged the enactment of a law, if it had been imagined to have any tendency to lower the exchangeable value of agricultural produce.

That the bounty had in fact no such tendency, we shall afterwards endeavour to show, but at present we shall only offer a few observations, explana-

* Wheat L. 12 Scots *per* boll; bear and barley L. 8 do.; oats and pease 8 merks.

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tory of the fall in the price of corn, posterior to 1699, which has, as it appears to us, without any sufficient reason, been ascribed to the operation of the bounty.

It is obvious, that no certain conclusions can ever be drawn as to whether the real value, that is to say, the expence of production of any commodity is diminished, merely from the fact of its *money* price having declined. In order to be able to form any accurate conclusions, as to the rise or fall of the real price of commodities, from the variations in their money price, it is essential to know, not only the state of the coin, as to purity or weight, but also, whether the value of bullion is itself stationary. A fall of money price will be as effectually produced by a rise in the value of gold and silver, as by a diminution of the cost of production; and the real price of a commodity may be increasing at the very time its nominal or money price is falling. To produce this effect it is only required, that the real price of bullion should increase still faster than the real price of the commodity with which it is compared.

Value of Gold and Silver in the early part of last Century.

That the real value of gold and silver rose in the early part of last century, has been maintained by Dr Smith, apparently on pretty good grounds. As no remarkable improvements in agriculture were then made, either in the continent or in England, the expence of producing corn may be reckoned to have remained nearly the same, or rather to have increased, as the general increase of population, however slow, would certainly cause recourse to be had to inferior soils. But, during this period, the money price of corn fell not only in this country, where a bounty was given on exportation, but in those continental kingdoms where exportation was prohibited. Conclusive evidence of this fact, as far as regards France, will be found in the table of the prices of wheat, at the Paris or Rosoy market, annexed to the very valuable work of Duprè de St Maur, entitled *Essai sur les Monnoies, ou Reflexions sur le Rapport entre l'Argent et les Denrees* Paris, 1746. And the table of the price of wheat at Seville, from 1675 to 1764 inclusive, published in the appendix to the *Bullion Report*, strongly confirms the reasoning of Dr Smith, and shows that prices had considerably declined in Spain, in the first 50 years of the last century.

The moral impulse imparted to this country by the revolution,—the abolition of all oppressive and arbitrary exactions,—and the number of intelligent and wealthy foreigners who then sought refuge in England, from the persecution of intolerant and bigoted governments, coupled with the revival of trade and the establishment of the Bank in 1694, caused an extension of commerce, and a considerable accumulation of capital in England, subsequently to the treaty of Ryswick. The wars of Queen Anne counteracted this progress; but during the long and pacific administration of Sir Robert Walpole, the increase of capital, and the improvement of every species of industry, though not so great as they afterwards became, continued uninterrupted. The rise of the money price of labour in Great Britain during that interval, is not therefore inconsistent with the fact of an advance in the value of the precious metals, but, as Dr Smith has stated, is a natural consequence of the improving state of the country, and of the increasing demand for labour. In France, which had been completely exhausted by the ruinous enterprises of Louis XIV., and where of course the demand for labour remained nearly stationary, wages *fell* as the price of corn declined. (*Wealth of Nations*, I. 313.)

State of the Coin in the reign of William III.

But whatever weight may be attached to these conclusions, respecting a general rise in the real value of gold and silver in the early part of last century, there can be no question as to the fact of a local rise having taken place in the value of the coin of this country, in consequence of the recoinage in the latter part of King William's reign. Silver, at that period, constituted the English standard of value; and to such an extent had this currency been debased by clipping, filing, &c., that, in 1695, the common price of silver bullion was 6s. 5d. *per* ounce, or 1s. 3d. above the mint price. A guinea then passed current for about 30s.; and the *nominal* exchange between London, and Holland, and Hamburgh, was rather more than 25 *per cent.* to the prejudice of the former. (*Wealth of Nations*, I. 304.) That this degraded state of the coin must have had the effect of raising the nominal price of every other commodity as well as bullion, would have been indisputably certain, although no direct evidence of the fact had been transmitted to us. Mr Lowndes, however, in his Report on the then state of the silver coin, particularly mentions its degradation as "*one great cause of the raising the price not only of all merchandises, but of every article necessary for the sustenance of the common people to their great grievance.*" (*Liverpool on Coin*, p. 70.) And Mr Locke, in his celebrated answer to Mr Lowndes' proposal for lowering the standard of the coin, confirms this statement, and asserts, that the nominal "*price of* ALL *sorts of provisions and commodities had risen excessively.*" (*Idem.*)

The *medium* rise in the nominal price of the undepreciated gold coin, and of silver bullion, when compared with the clipped and degraded coin, appears, from the statements of Messrs Locke and Lowndes, to have rather exceeded 30 *per cent.* And it is of importance to remark, that, in 1700, the year in which the new coin came into general circulation, the market price of corn, which had previously been rising, *declined to very near the same extent.* That this fall may, in some degree, have been owing to a luxuriant crop, is not improbable; but that the increased value of the circulating medium would of itself have speedily lowered the nominal price of corn, and every other commodity, is quite certain.

Mr Charles Smith, Mr Malthus, and other writers, who contend that a bounty on the exportation of corn has a tendency to lower its price, admit that the bounty granted in 1688 had no such effect anterior to 1700! This fact ought certainly to have stimulated these gentlemen to inquire, whether nothing peculiar belonged to that year. They should have recollected, that a fall of nominal prices will be as effectually brought about by a rise in the value of the currency, as by

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a fall in the value of the commodities for which it is exchanged. If they had kept this principle in view, and adverted to the circumstances under which the recoinage of 1696, 1697, and 1698 took place, perhaps they would not have made their assertions respecting the effects of the bounty in so very confident a manner; and, at all events, they would not have adduced the fall of prices in 1700, and subsequently, as any proof of their correctness.

We do not certainly mean to affirm that the *whole* rise of price, from 1692 to 1698 inclusive, is to be ascribed to the depreciation of the currency. Undoubtedly the bounty, and perhaps, too, bad seasons, contributed to produce this rise; and, had there been no bounty, prices would, in all probability, have fallen still lower after the recoinage.

In considering the effects of the bounty, it ought always to be recollected, that prices had been gradually falling previously to its being granted.

From 1649 to 1658, the average price of the Winchester quarter of middling wheat was . . .	L. 2	7	0
From 1659 to 1668 . . .	2	6	8
From 1669 to 1678 . . .	2	3	4
From 1679 to 1688 . . .	1	18	4*

The bounty was given with the avowed intention of checking this fall, and was, in our opinion, well calculated to accomplish its object. But, whatever may have been its effects, it can never be assigned as any cause of the fall of prices between 1700 and 1746, when that very fall had begun thirty years before it was granted, and when prices rose in the first ten years of its existence.

Perhaps part of the fall of corn in England, subsequent to 1640, may be justly ascribed to the prohibition of the export of wool, which, after several previous attempts, was carried into full effect by the act of 1660. The wool formerly raised in Great Britain having much exceeded what was required for our manufactures, its price declined as soon as its export was put an end to; and, of course, some portion of the soil employed in rearing sheep would be brought under tillage, and a greater quantity of good land, besides an additional capital, would be turned to the raising of corn.

Although the mint price of gold had been reduced by King William, it was still rated too high as compared with silver; and, consequently, the currency again became deranged. The deficiency of new silver coin, caused by the inducement to melt it down, could not be immediately experienced, but towards the latter part of Queen Anne's reign, a want of silver, and a considerable difficulty in making payments, were universally felt and complained of. As might have been expected, *prices rose*, and from 1709 to 1717, both inclusive, were much above the average of the eight preceding or of the following years. That this could not be an effect of deficient crops is evident, from the fact of a considerable exportation, forced, no doubt, to a certain extent, by the bounty, having then taken place. The government did not indeed entertain any such opinion, but having wisely adopted the suggestion of Sir Isaac Newton, and reduced the mint value of the guinea, the melting and hoarding of silver ceased, and prices, as in 1700, fell to their former level.

In accounting for the low price of corn in the reigns of George I. and George II., after allowing for the increased value of the coin, the effects of the relaxation of the laws against forestallers and engrossers must not be forgotten. Large capitals were now engaged in the corn trade, and extraordinary fluctuations in its price were thereby avoided. The home demand was rendered more steady and equal; while the perfect security of property, and the greater political influence attached to landed possessions, naturally attracted a more than ordinary portion of the accumulating capital of the country towards agriculture.

The bounty, by extending the foreign market, no doubt contributed materially to the extension of cultivation, although, by forcing recourse to be had to worse soils in order to obtain the additional supplies of corn, it must have raised prices. In the period from 1740 to 1751, the cheapest in last century, the bounties paid on exportation amounted in all to L. 1,515,000; and in 1749 alone they somewhat exceeded L. 324,000. The bounty, however, had by this time been much too long in operation to permit the growers or exporters to realize any but the common and ordinary profits of stock; and, therefore, if it had never been granted, not only the quantity of corn exported, but the home price, which must have been regulated by the expence *necessary* to produce the increased supply required by the bounty on the poorest soils in cultivation, would have been reduced. We shall afterwards elucidate this principle at greater length; but it is of importance to remark how much this forced exportation must have raised the real price of corn, at the very time when it is supposed to have reduced it.

Diminution of Exports subsequent to 1750.

But notwithstanding the factitious stimulus thus given to exportation, the quantity of exported corn, which, in 1750, had amounted to 1,667,778 quarters of all sorts, rapidly diminished; and the gradual increase of the home demand, in the last ten years of the reign of George II. accompanied as it was by a rise of prices, reduced the annual average exportation, at the accession of his present Majesty, to about 600,000 quarters. After the peace of Paris, in 1763, the national improvement was prodigiously accelerated. The extension of industry caused by the acquisition of new branches of commerce, by the increase of our colonial possessions, and perhaps, more than all the rest, by the introduction of improved machinery into the cotton manufacture, † was followed by a sudden increase of the population, and, as importation was prohibited, by a corresponding rise of prices.

* See Table of Prices of Wheat at Eton College, annexed to this Article.

† Jennies were invented in 1766, by Richard Hargreaves, Weaver in Lancashire, who, to the disgrace of his age and nation, was suffered to pass his days in obscurity and poverty.

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The admirers of the restrictive system have generally reasoned, as if this rise of price and the cessation of exportation had been a *consequence* of the alteration made in the corn laws in 1773. But it should be carefully observed, that this very alteration was an avowed, and a necessary consequence of the *previous* rise. In 1765, before any suspension of the restrictive system had taken place, the balance on the side of wheat exported, only amounted to 77,000 quarters, and the home price in this and the two preceding years had risen to an unusual height. The very general and growing dissatisfaction at continuing the prohibition against importing, in these circumstances, produced a suspension of the high duties in 1766; and by temporary enactments, this suspension (accompanied occasionally with restrictions on exportation) was continued to 1773, when a permanent act was framed, by which foreign wheat was allowed to be imported, on paying a nominal duty of 6d. whenever the home price reached 48s. a quarter; and the bounty and exportation were together to cease when the price reached 44s. This statute also permitted the importation of corn at any price, in order to be again exported, duty free, provided it was, in the meantime, lodged under the joint locks of the King and the importer.

Statute of 1773.

The prices, when exportation was to cease, seem here to have been fixed too low; and, as Dr Smith has observed, there appears a good deal of impropriety in prohibiting exportation altogether at the precise prices at which that bounty which was given, in order to force it, is withdrawn; yet with all these defects, the act of 1773 was a most material improvement on the former system, and ought not to have been altered unless to render the trade perfectly free.

The idea that this law must, when enacted, have been injurious to the farmers, seems altogether illusory. The permission to import foreign grain, when the home prices rose to a certain rate, certainly prevented their realizing exorbitant profits at the expence of the other classes, and prevented an unnatural proportion of the capital of the country being turned towards agriculture. But as this rate was fixed very considerably higher than the average price in the reign of George II. it cannot be maintained that it had any tendency to lower previous prices, which alone could discourage agriculture; and in fact no such reduction took place.

It is indeed true, that, but for this act, we should not have imported so much foreign grain in the interval between 1773 and 1791. This importation, however, was no consequence of the declining state of our agriculture, for it is universally admitted that every department of rural economy was more improved in that period than in the whole course of the preceding century; but arose entirely from a still more rapid increase of the manufacturing population, and hence of the effective demand for corn.

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By referring to the tables of exports and imports annexed to this article, it will be seen, that, in 1772, the balance on the side of wheat *imported*, amounted to 18,515 quarters; and in 1773, 1774, and 1775, all years of great prosperity, this balance was very much increased. The loss, however, of a great part of our colonial possessions, and the general stagnation of commerce, occasioned by the American contest, having diminished the consumption, the balance was high on the side of exportation in 1778, 1779, and 1780. In 1783 and 1784, the crop was unusually deficient, and considerable importations took place, but in 1785, 1786, and 1787, the exports again exceeded the imports; and it was not till 1788, when the country had fully recovered from the effects of the war, and when manufacturing improvements were carrying on with extraordinary spirit, that the imports permanently overbalanced the exports.

Increase of Produce between 1773 and 1791.

The growing wealth and commercial prosperity of the country had thus, by increasing the population, and enabling individuals to consume additional quantities of food, caused the home supply of corn to fall somewhat short of the demand; but it must not therefore be concluded, that agriculture had not at the same time been very greatly ameliorated. "The average annual produce of wheat," says Mr Comber, "at the beginning of the reign of his present Majesty, was about 3,800,000 quarters, of which about 300,000 had been sent out of the kingdom, leaving about three and a half millions for home consumption. In 1773, the produce of wheat was stated to the House of Commons to be four millions of quarters, of which the whole, and above 100,000 imported, were consumed in the kingdom. In 1796, the consumption was stated in the House of Commons, by Lord Hawkesbury, to be 500,000 quarters *per* month, or six millions annually, of which about 180,000 were imported, showing an increased produce, in about 20 years, of 1,820,000 quarters. It is evident, therefore, not only that no defalcation of produce had taken place, in consequence of the cessation of exportation, as has been too lightly assumed, from the occasional necessity of importation; but that it had increased with the augmentation of our commerce and manufactures." (Comber *on National Subsistence*, p. 180.)

These estimates are, no doubt, very loose and unsatisfactory, but the fact of an increase of produce is unquestionable. In the Report of the House of Commons on the state of the *waste lands*, drawn up in 1797, the number of acts passed for enclosing, and the number of acres enclosed, in the following reigns, are thus stated:

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	Number of Acts.	Number of Acres.
In Queen Anne's reign,	2	1,439
In George I. -	16	17,660
In George II. -	226	318,778
In George III. to 1797,	1,532	2,804,197.*

It deserves particular notice, that, from 1771 to 1791, both inclusive, the period in which these great agricultural improvements were carrying on, there was NO RISE of prices.

Statute of 1791.

The landholders, however, could not but consider the liberty of importation granted by the act of 1773 as injurious to their interests, inasmuch as it prevented prices from rising with the increased demand. A clamour, therefore, was raised against that law; and, in addition to this interested feeling, a dread of becoming habitually dependent on foreigners for supplies of corn operated with many, and produced a pretty general acquiescence in the act of 1791; by which the price, when importation could take place from abroad, at the low duty of 6d., was raised to 54s., under 54s., and above 50s., a middle duty of 2s. 6d., and under 50s. a prohibitory duty of 24s. 3d. was exigible. The bounty continued as before, and exportation without bounty was allowed to 46s. It was also enacted, that foreign wheat might be imported, stored under the King's locks, and again exported free of duty; but, if sold for home consumption in the kingdom, it became liable to a warehouse-duty of 2s. 6d. in addition to the ordinary duties payable at the time of sale.

Mr Comber has justly blamed this imposition of duties on the warehousing of foreign corn; but the deficient crops of 1795 and 1797, followed, as they were, by a great rise of prices, superseded these provisions, and even caused the granting of high bounties on importation.

In 1797 the Bank had been restricted from paying in specie, and the consequent facility of obtaining discounts and getting a command of capital, gave a fresh stimulus to agriculture; the efficacy of which was most powerfully assisted by the great scarcity and high prices of 1800 and 1801. An agricultural mania had now seized the nation, and as the prices of 1802 and 1803 would not have permitted the cultivation of the poor soils which had lately been broken up, a new corn law was loudly called for by the farmers, and passed in 1804. This act went directly to the point. It imposed a prohibitory duty of 24s. 3d. *per* quarter on all wheat imported when the home price was at or below 63s.; between 63s. and 66s. a middle duty of 2s. 6d. was paid; and above 66s. the nominal duty of 6d. The price at which bounty was allowed on exportation was extended to 40s. and importation without bounty to 54s. By the act of 1791, the maritime counties of England had been divided into 12 districts, and importation and exportation had been regulated by the particular prices of each; but, by the act of 1804, they were regulated in England by the *aggregate average* of the 12 maritime districts, and in Scotland by the *aggregate average* of the four maritime districts. The averages, as at present, were taken at four periods in the year, and the ports could not remain open or shut for less than three months. This method of ascertaining prices was, however, modified in the following season, and it was then fixed that the importation both in England and Scotland should be regulated by the average price of the whole twelve maritime districts.

Statute of 1804, increasing the Duties on Importation.

To prohibit the importation of the necessaries of life into any country where the supply is short of the demand, till prices rise to a certain height, has a direct tendency to raise them still higher. British merchants would not at present (June 1818) order foreign grain, if the home price was steady at about 80s. It could not, in fact, be imported to any extent, unless the price was considerably higher, because it is certain that the dreaded effect of a large importation would of itself suffice to sink the market price, and would consequently put a stop to the influx. In 1805 the crop was very considerably deficient, and the average price of that year was about 22s. above the price at which importation was allowed by the act of 1804. The depreciation of paper compared

* The following is a statement of the Acts of Parliament passed for local improvements, commencing with 1785, and ending with 1816.

	Total of Eight Years, ending 1792.	Total of Eight Years, ending 1800.	Total of Eight Years, ending 1808.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	Total of Seven Years, ending 1816.
For roads and bridges	302	341	419	52	58	53	47	53	44	34	341
For canals, harbours, &c. - -	64	132	127	9	15	13	7	6	10	4	64
For dividing, enclosing, and draining,	245	589	757	114	134	123	117	119	82	49	738
For parochial and city improvements,	139	62	141	25	17	24	20	21	26	22	115
Totals,	750	1,124	1,444	200	222	213	191	199	162	109	1,298

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with bullion, being at that time about four *per cent.* the high price of that year must have been owing to the operation of the new corn law preventing any importation of foreign grain till the home price was high, and then cramping mercantile operations; and to the war rendering the cost of importation unusually great. In 1806, 1807, and 1808, the depreciation of paper, compared with bullion, continued at nearly four *per cent.*; and the price of wheat in these years being generally from 66s. to 75s. a small importation only took place. From autumn 1808 to spring 1814, the depreciation of our currency was rapid beyond all former example; and several crops in that interval being likewise deficient, the money price of corn, influenced by both causes, rose to a surprising height. The following is a statement of the money or *paper* price, and the *bullion* price of corn, from 1809 to 1814 both inclusive:

Paper Price per Quarter.		Bullion Price per Quarter.	
1809	95s. 7d.	1809	81s.
1810	106s.	1810	88s. 6d.
1811	94s.	1811	74s.
1812	125s. 6d.	1812	98s. 6d.
1813	100s. 9d.	1813	73s.
1814	74s.	1814	56s. 6d.

The crops of 1809 and 1810 were much below an average, and the *bullion* price of these years is a good deal higher than the importation price of 1804. This excess is to be ascribed partly to that law, and partly to the extraordinary difficulties then thrown in the way of importing grain. At that time no vessel could be loaded in any Continental port for England, without purchasing a licence; and the freight and insurance were at least *four* times as high as during peace. The same causes operated in 1812; but, in the autumn of 1813, the destruction of Bonaparte's anti-commercial system having increased the facilities of importation, a large quantity of corn was poured into the kingdom; and, in 1814, its *bullion price* was reduced below the point at which importation was allowed.

Before this fall of price, a committee of the House of Commons had been appointed to inquire into the state of the laws affecting the corn trade: and their *Report* (dated 11th May 1813) recommended a very great extension of the rates at which exportation was formerly allowable, and when importation free of duty could take place. The recommendation of this committee was not adopted by the House; but the fact of its having been made when the home price was at least 112s. *per* quarter, displays a surprising solicitude to exclude foreigners from all competition with the home growers.

Proceedings respecting the Alteration of the Corn Laws in 1814.

The lessening of the dependence of the country on foreign supplies formed the sole ostensible ground on which this committee had proposed any alteration in the act of 1804. But after the fall of price in autumn 1813, and in the early part of 1814, it became obvious, on comparing our former prices with those of the continent, that, without an alteration of the existing law, this dependence would be considerably increased; that a good deal of the poor lands, which the previous high prices had forced into cultivation, would be again thrown into pasturage, and that a corresponding reduction of rent would be experienced. These consequences alarmed the landlords and landholders, and, in the early part of the session 1814, a new set of resolutions were voted by the House, declaring that it was expedient to repeal the bounty, and to permit the free exportation of corn, whatever might be the home price, and to impose a graduated scale of duties on the importation of foreign corn. Thus, foreign wheat imported when the home price was at or under 64s. was to pay a duty of 24s.; when at or under 65s. a duty of 23s. and so on, till the home price should reach 86s. when the duty was reduced to 1s., at which sum it became stationary. Corn imported from Quebec, or from the other British colonies in North America, was to pay only half the duties on other corn. As soon as these resolutions had been agreed to, two bills founded on them, one for regulating the importation of foreign corn, and another for the *repeal of the bounty*, and for permitting unrestricted exportation, were introduced. Very little attention was paid to the last of these bills, but the one imposing fresh duties on importation encountered a very keen opposition. The manufacturers, and every class not directly supported by agriculture, stigmatized it as an unjustifiable attempt fictitiously to keep up the price of food, and to secure excessive rents, and large profits to the landlords and farmers, at the expence of the consumers. Meetings were very generally held and resolutions entered into, strongly expressive of this sentiment, and dwelling on the fatal consequences, that a continuance of the high prices would have on our manufactures, in a season of peace, when we could no longer exclusively monopolize the commerce of the world. This determined opposition, coupled with the indecision of ministers, and perhaps, too, with an expectation, on the part of some of the landlords, that prices would again rise, without any legislative interference, caused the miscarriage of this bill: The other was passed into a law.

Report on the Corn Trade and Laws, presented in 1814.

Committees of both Houses of Parliament had been appointed in 1814, to examine evidence and to report on the state of the corn trade, and a great number of the most eminent agriculturists in the kingdom were examined. The witnesses were unanimous in this only, that the protecting prices, fixed in 1804, were insufficient to enable the farmers to make good the engagements into which they had subsequently entered, and to continue the cultivation of the inferior lands, lately brought under tillage. Some of them thought 120s. ought to be fixed as the price when the importation of wheat free of duty should be allowed: others varied from 90s. to 100s.; from 80s. to 90s.; and a few from 70s. to 80s. The general opinion, however, seemed to be, that 80s. would answer; and, as prices continued to decline, a set of resolutions, founded on this assumption, were submitted to the House of Commons by Mr Robin-

son of the Board of Trade * (for government had now determined to support the measure), and having been agreed to, a bill founded on them was, after a very violent opposition, carried in both Houses by immense majorities, and finally passed into a law. 55th Geo. III. c. 26.

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* *Resolutions respecting the Corn Trade, submitted to the House of Commons, February* 17, 1815.

1*st*, That it is the opinion of this Committee, that any sort of foreign corn, meal, or flour, which may by law be imported into the United Kingdom, shall at all times be allowed to be brought to the United Kingdom, and to be warehoused there, without payment of any duty whatever.

2*d*, That such corn, meal, and flour, so warehoused, may at all times be taken out of the warehouse, and be exported, without payment of any duty whatever.

3*d*, That such corn, meal, or flour, so warehoused, may be taken out of the warehouse, and be entered for home consumption in the United Kingdom, without payment of any duty whatever, whenever foreign corn, meal, or flour, of the same sort shall be admissible into the United Kingdom for home consumption.

4*th*, That such foreign corn, meal, or flour, shall be permitted to be imported into the United Kingdom, for home consumption, without payment of any duty, whenever the average prices of the several sorts of British corn, made up and published in the manner now by law required, shall be at or above the prices hereafter specified, viz.

	per Quarter.
Wheat, ...	80s.
Rye, pease, and beans, ...	53s.
Barley, bere, or bigg, ...	40s.
Oats, ...	26s.

But that whenever the average prices of British corn shall, respectively, be below the prices above stated, no foreign corn, or meal, or flour, made from any of the respective sorts of foreign corn above enumerated, shall be allowed to be imported or taken out of warehouse for home consumption, nor shall any foreign flour be at any time importable into Ireland.

5*th*, That the average prices of the several sorts of British corn, by which the importation of foreign corn, meal, or flour, into the United Kingdom is to be regulated and governed, shall continue to be made up and published in the manner now required by law; but that hereafter, if it shall at any time appear that the average prices of British corn, in the six weeks immediately succeeding the 15th February, 15th May, 15th August, and 15th November in each year, shall have fallen below the prices at which foreign corn, meal, or flour, are by law allowed to be imported for home consumption, no such foreign corn, meal, or flour, shall be allowed to be imported into the United Kingdom, for home consumption, from any place between the rivers Eyder and Garrone, both inclusive, until a new average shall be made up and published in the London Gazette, for regulating the importation into the United Kingdom for the succeeding quarter.

6*th*, That such corn, meal, or flour, being the produce of any British colony or plantation in North America, as may now by law be imported into the United Kingdom, may hereafter be imported for home consumption without payment of any duty, whenever the average prices of British corn, made up and published as by law required, shall be at or above the prices hereafter specified, viz.

	per Quarter.
Wheat, ...	67s.
Rye, pease, and beans, ...	44s.
Barley, bere, or bigg, ...	33s.
Oats, ...	22s.

But that whenever the prices of British corn respectively shall be below the prices above specified, corn, or meal, or flour, made from any of the respective sorts of corn above enumerated, the produce of any British colony or plantation in North America, shall no longer be allowed to be imported into the United Kingdom for home consumption.

7*th*, That such corn, meal, or flour, the produce of any British colony or plantation in North America, as may now by law be imported into the United Kingdom, shall at all times be permitted to be brought there and warehoused, without payment of any duty whatever.

8*th*, That such corn, meal, or flour, so warehoused, may at all times be taken out of the warehouse and exported, without payment of any duty whatever.

9*th*, That such corn, meal, or flour, so warehoused, may be taken out of warehouse, and entered for home consumption in the United Kingdom, whenever corn, meal, or flour, of the like description, imported direct from any such colony or plantation, shall be admissible for home consumption, but not otherwise.

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Irish Corn Laws.

The policy on which the corn trade of Ireland has been conducted during the last century, is not materially different in its *principles* from that followed in Great Britain. In 1707, the Irish Parliament, by a statute framed in imitation of the English bounty act of 1689, granted a bounty of 1s. 6d. *per* quarter on every quarter of wheat exported, when the price was at or under 14s.; of 1s. on the quarter of barley, bere, or bigg, when at or under 10s.; and of 1s. on the quarter of oats when at or under 9s. This act, however, did not, by any means, place the Irish agriculturists on the same footing with those of Great Britain. The bounty scarcely exceeded *one-fourth* part of what had been granted in this country; and Mr Newenham has shown, that the prices, when it became payable, were fixed much below the average rate at the time. (*Natural and Political Circumstances of Ireland*, p. 124.)

Although we are very far, indeed, from imagining, that Ireland lost any thing by this different treatment, it at least shows the spirit which then influenced the English Government in its conduct towards that country. If bounties were really beneficial, as they were then supposed to be, Ireland surely had a right to every advantage that could have been derived from them. We had just succeeded in putting a stop to her rising progress in the woollen manufactures; and if the government of England, and its dependents in the Irish Parliament, had not been actuated by a mean and illiberal jealousy of the advancement of Irish agriculture, as well as of Irish manufactures, the same encouragements to cultivation would doubtless have been held forth in both countries.

The bounty continued to be regulated by the act of 1707 till 1755, when its mode of payment was changed; but the amount remained nearly the same. In the reign of his present Majesty, however, a different policy was adopted, and several consecutive laws (5th Geo. III. c. 19, 13th and 14th Geo. III. c. 11, 19th and 20th Geo. III. c. 17) were enacted, by which the bounties were greatly enlarged. At last, in 1784, the celebrated statute, 23d and 24th Geo. III. c. 19, was passed, by which a bounty of 3s. 4d. was granted on every barrel of wheat weighing 20 stone exported, when the home price was at or under 27s.; of 1s. 7d. on the barrel of barley, bere, and bigg, weighing 16 stone, when at or under 13s. 6d.; and of 1s. 5d. on the barrel of oats, weighing 14 stone, when at or under 10s. These high bounties, coupled with the prohibitory duties imposed at the same time on importation, amounting to 10s. the barrel on wheat, when the home price was at or under 30s.; on barley 10s. when at or under 14s. 6d.; and on oats 5s. when at or under 11s.; gave an extraordinary stimulus to cultivation, and soon caused a very great increase of tillage, and in the exports of corn from Ireland.

Bounty Act of 1784.

Effects of the Bounty Act of 1784.

It is extremely doubtful, however, notwithstanding the encomiums which have been lavished on the act of 1784 by Mr Newenham and others, whether this increase of tillage has not been really prejudicial. The nature of the soil, and the humidity of the climate, render Ireland much better fitted for pasturage than for cropping. Mr Young, who is certainly a very competent judge of such matters, asserts, that wheat, and other kinds of grain raised in that country, are decidedly inferior in quality to those of Britain; that the crops too, even under the best management, are full of grass and weeds; and that the harvests are generally wet and tedious. Now, surely the *mere extension* of tillage under such circumstances, and this has really been the whole effect of the bounty, could not possibly be advantageous. If the agriculture of Ireland had been improved, if more produce had now been obtained with less labour than formerly, and if the cottage system, the bane and curse of that kingdom, had been losing ground,—it might have been justly contended, that the immediate effects of the bounty had been beneficial. But it has not had, and could not rationally be expected to have, any such consequences. "Perhaps," says Mr Wakefield, "I shall be told that Ireland, under the present system, is improving, and that rents, of late years, have considerably risen. Rents will rise by an extension, as well as by an improvement of tillage; * they will rise from an increase in the price of produce, and it is well known that they have risen in consequence of an enlargement of circulating medium. To these causes I ascribe the latter circumstance, the truth of which I fully admit, though I absolutely deny the former. If any one will show me farming buildings of a late erection, or point out a single plough of a proper construction, in the hands of an Irish farmer, whose only means of support is the cultivation of the soil, I will allow that some improvement has taken place. Is any competent judge prepared to say, that fewer acres, in proportion to the whole tillage land, are cultivated with the spade, than there were twenty years ago? Some, perhaps, may consider this system as beneficial, by affording employment to the people; but, it might be observed on the other hand, that to count the grains of wheat in every barrel, would furnish them employment also. In every case of this kind we ought to look to the result; for employment is useful only as it becomes productive." (*Account of Ireland, Statistical and Political*, Vol. I. p. 582.)

It appears much more reasonable to ascribe any real improvement which may have taken place in Ireland since 1784, to the comparative degree of freedom then conferred on that country,—to the abolition of various restrictions previously imposed on its industry,—and, above all, to the political privileges conferred on the Catholics,—rather than to the mere granting a bounty on the export of corn.

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* Such improvements in agriculture as enable a greater quantity of produce to be procured with the same expenditure of capital and labour, instead of increasing, *lower* rent. It is by the investment of capital, with a *diminished* return, and by the bringing of poorer lands under cultivation, that rent is really raised.

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A great proportion of the people were formerly a degraded sect, viewed with jealousy and aversion by the ruling few, and deprived of all political power; and it was natural to expect that a very marked improvement in their circumstances should take place, after they had been in some measure restored to the enjoyment of their natural rights; and after they had become really interested in the improvement of their country. This, in our opinion, is the chief source of the recent improvement of Ireland, which, instead of being accelerated, has been kept back by the bounty. By suddenly raising prices, that measure certainly stimulated the cultivation of the soil; but the want of capital, and the consequent difficulty of finding farmers capable of taking large farms, coupled with the general predilection of the people in favour of small ones, have conspired to cause a still more minute division of property, and to give a factitious stimulus to the production of an overabundant and morbid population. It is not, it must be recollected, by the mere fact of an increase in the numbers of a people (and it is on this that Mr Newenham principally relies, when contending for the favourable effects of the bounty) that we can determine as to whether it has been really beneficial. If it were possible, and we trust it is not, to give the English and Scottish peasants the same habits as those of Ireland,—to render them satisfied with potatoes, with mud cottages, and with rags and wretchedness,—their numbers would rapidly increase; but it would, at the same time, be indisputable that their situation would be altered very much to the worse. In the same way, if we could inspire the people of Ireland with the same taste for superior comforts, for cleanliness, and for good living, which so eminently and honourably distinguishes the same class in England, their number would perhaps be diminished, but their social condition would certainly be rendered much more enviable than at present. More happiness, more independent feeling, more, in short, of every thing that is either desirable or praiseworthy, will be found in a country possessed of 100,000 well fed, well clothed, and well educated inhabitants; than are to be found in a nation peopled with multitudes of human beings pressing against the limits of subsistence, and sunk in poverty and ignorance.

The endeavouring to impress on the minds of the lower classes the propriety of being contented with the simplest and cheapest fare, is extremely pernicious to the best interests of mankind. Encomiums ought not to be bestowed on those who are contented with mere necessaries. On the contrary, such indifference ought to be held disgraceful. A taste for the comforts, the enjoyments, and even the luxuries of life, should be as widely diffused as possible, and if possible interwoven with the national character and prejudices. This, as it appears to us, is the best mode of attempting the amelioration of the condition of the lower classes. Luxurious, and, if you will have it so, even wasteful habits, are incomparably better than that cold, sluggish apathy, which would content itself with what can barely continue mere animal existence. "In those countries," Mr Ricardo judiciously observes, "where the labouring classes have the fewest wants, and are contented with the cheapest food, the people are exposed to the greatest vicissitudes and miseries. They have no place of refuge from calamity; they cannot seek safety in a lower station; they are already so low, that they can fall no lower. On any deficiency of the chief article of their subsistence, there are few substitutes of which they can avail themselves, and dearth to them is attended with almost all the evils of famine."

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The corn law of 1804, the first framed subsequently to the Union, extended to Ireland, and the price at which the bounty became payable on the exportation of wheat from that country, was raised to 29s. 4d. *per* barrel, and of rye to 20s. 4d.; the price at which the bounty was given on the exportation of oats remained the same, and almost no alteration was made on the amount of the bounties themselves.

Act of 1806, establishing Freedom in the Corn Trade between Britain and Ireland.

But the shackles which an absurd policy had, at different times (See 33d Geo. III. c. 65, 42d Geo. III. c. 35, 44th Geo. III. c. 65, &c.), imposed on the free importation and exportation of corn between Great Britain and Ireland, were not removed by the act of 1804. These impolitic restraints were, however, abolished very soon after; and the act of 1806 (46th Geo. III. c. 97), which established a perfect freedom in the corn-trade between the two great divisions of the empire, has, perhaps, contributed more to its general advantage and prosperity, than any other enactment framed in this reign.

The provisions of the late act regulating export and import, are the same in Ireland as in Great Britain. The averages, however, by which the opening and shutting of the ports are regulated, are framed with reference to the price of British corn only; and as prices are always lower in Ireland than in this country, the restriction on importation will there operate most efficaciously. *

II. Principles of the Corn Laws.

Having completed this sketch of the History of the Corn Laws, we shall now briefly examine the Principles on which they have been founded: And as there exists no difference of opinion respecting the propriety of giving an unbounded freedom of exportation, we shall confine our inquiries to the policy of encouraging this exportation by means of a bounty, and of laying restrictions on importation.

That this subject may be properly understood, it is necessary to premise, that the value of corn, like that of every other commodity, is regulated, in every stage of society, solely *by the greater or less quantity of labour necessary to its production under the most*

* Our readers will find a very ample and instructive discussion respecting the effects of the inland bounty on the importation of corn into Dublin, in the Appendix to Mr Young's *Tour in Ireland*.

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*unfavourable circumstances.** A bushel of wheat might be obtained from the rich soil in the Carse of Gowrie, at a half or a third of the expence necessary to produce it in less favoured situations, and might therefore be sold for a half or a third of the price of the other. But, if the demand is such as requires the cultivation of inferior lands, the price of the produce of the richer lands must be elevated to such a height as will admit of the ordinary profits of stock being realized on the poorest. If it were not raised to this height, the cultivation of the inferior lands would be abandoned, and the necessary supplies of food would no longer be obtained.

Circumstances regulating the exchangeable Value of Raw Produce.

In the earlier stages of society, and whenever the population is very limited, the best lands only will be cultivated; and as they will yield a large produce with comparatively little labour, its relative or exchangeable value will be proportionably low. But, as society advances, and as the population becomes more numerous, recourse must be had to inferior soils. A greater expenditure of capital and labour will then be required to produce the same quantity of corn; and, of course, the value of corn, compared with other commodities, in the production of which no additional quantity of labour had been required, must be increased.

The raising of raw produce is, therefore, extremely different from every other species of industry. In manufactures, the worst machinery is first set in motion, and every day its powers are improved; and it is rendered capable of yielding a greater amount of produce with the same expence. The discovery of a new machine, or of a more expeditious and less expensive mode of manufacturing, very soon supersedes the older and clumsier machinery previously in use; while the consequent competition never fails to reduce the price of commodities to the sum which the least expensive method of production, necessarily requires for their manufacture.

In agriculture, on the contrary, the best machinery, that is, the best soils, are first brought under cultivation, and recourse is afterwards had to inferior soils, requiring a greater expenditure of capital and labour to produce the same supplies. The improvements made in the construction of farming implements, and the ameliorations of agricultural management which occasionally occur in the progress of society, really reduce the price of raw produce; and, operating like the improvements made in manufacturing machinery, so far assimilate the two species of industry. Any fall, however, which may take place in the real price of raw produce, as it will enable every class of society to procure a greater quantity of it than before, in exchange for their manufactured commodities, or for their labour, must raise the profits of stock; and, of course, must lead to an increased accumulation of capital. But the industry of a nation being always in proportion to the amount of its capital, "this accumulation necessarily leads to a greater demand for labour, to higher wages, to an increased population, and consequently to a further demand for raw produce, and to an increased cultivation." (Ricardo, *Principles, &c.* p. 70.) Agricultural improvements check, for a time, the necessity of having recourse to inferior soils, but the check can only be temporary. The stimulus which they, at the same time, apply to population, soon equalizes the demand with the supply, and, by a re-action of a different kind, raises prices, and forces the cultivation of poor lands.

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The exchangeable value of raw produce, therefore (though improvements in agriculture, and other circumstances, may occasionally reduce it), has a natural and constant tendency to rise as society advances. As it becomes more difficult to raise food, it necessarily exchanges for a greater quantity of other produce. Not merely its nominal, but its real price is increased; and no person can have the same command over it as before, without making a proportionably greater sacrifice of labour, or of some other equivalent.

It is this circumstance, and not the accumulation of capital, which, in all old settled and populous countries, by raising wages, reduces the profits of stock, and checks, or at least retards, their future progress. The exchangeable value of a commodity not being regulated by the price at which the labour necessary to its production is paid, *but by the quantity of that labour*, it is obvious that every increase in the wages of workmen must lessen that share of the commodity they manufacture, which belongs to the capitalist, or, what is the same thing, must lessen the profits of stock.

Supposing the value of money to be invariable, and the quantity of labour necessary to produce L.1000 worth of gloves to remain the same, the gloves would continue to sell for that sum, whether the wages of the labour necessary to their production amounted to L.600, to L.800, or to L.900. The rise of wages, it must be remembered, is supposed to be quite general; and hence, if the L.1000 worth of gloves had freely exchanged before wages rose for a certain quantity of boots, stockings, coats, &c. they will do the same thing afterwards, unless the labour necessary for the manufacture of these other commodities has been increased or diminished; for, it is evident that a rise of wages which equally affects different commodities leaves their relative values unaltered.

An Increase in the Wages of Labour always reduces the Profit of Stock.

If the rise of wages was not universal, and if the glove manufacturer alone had to pay, say 10 *per cent.* additional on the wages of his workmen, while the manufacturer of boots, stockings, coats, &c. paid only the former rate of wages, he would either have to obtain a greater quantity of these commodities in exchange for his gloves, or he would be forced to abandon his trade altogether. But such a state of things could not possibly continue. There would immediately be an influx of labourers into the glove manufactory; and their increase in one department of

* For a complete demonstration of this most important and fundamental principle, see Mr Ricardo's excellent work on the *Principles of Political Economy and Taxation.*

[Pr]inciples of the [Co]rn Laws.

industry, and consequent diminution in the rest, would very speedily adjust wages to the same level. As soon, however, as this adjustment had taken place, the relative or exchangeable values of these different commodities would be precisely the same as before the rise of wages. The glove manufacturer could not say to the stocking manufacturer that he must now have a greater quantity of stockings in exchange for his gloves, because he paid a higher rate of wages, for the other would have it in his power to answer that the same rise affected him to exactly the same extent. Commodities would, therefore, continue to sell after the rise for the very same price as before, but the proceeds would be differently divided. A greater share would belong to the labourer, and a less to the capitalist, or, what is the same thing, *the profits of stock would be diminished.*

The fluctuations in the value of money obscure, but do not in the smallest degree affect the relation between profits and wages. A rise or fall in the *real* wages of labour, the only one we are here considering, results entirely from a greater or less proportion of its produce belonging to the different classes of workmen and capitalists. When a greater share is assigned to the workman at one period than another, his wages are really augmented, and when a smaller share, they are as really diminished, whatever may be the state of *money* wages. *

[Eff]ect of a [Hig]h Price [of] Provi[sion]s on [Wa]ges.

It has, indeed, been contended, that the price of labour has no connection with the price of food, and that the former being regulated solely by the state of the supply and the demand, the enhancing of the price of corn does not necessarily cause any increase in the wages of labour, and consequently does not tend to reduce the profits of stock. But the cost of rearing and maintaining labourers, independent of all other considerations, determines the very lowest limit to which the prices of labour can permanently fall. In a manufacturing country the rate of wages is, no doubt, exposed to great fluctuations, and a stagnation may take place in trade at the same time that corn is rising, and the labouring class may at once experience an increase in the price of provisions and a fall of wages. But, if this rise in the price of corn be of a permanent nature, and if manufacturers do not allow a corresponding rise in the price of labour, the *principle of population* will begin to operate, and, by lessening the supply of workmen, will ultimately raise wages to their proper level.

It may perhaps be objected, that this is too rigorous a view of the matter, and that in countries where labour has been well rewarded, and where not more than *one-third* or *two-fifths* of the wages of workmen have been directly expended in the purchase of corn, an increase in the price of bread and meal would rather serve as an inducement to retrench from what was not essentially necessary, than to lessen the supply of hands. Few, however, if any, of the countries of Europe are in this situation; and, as labourers constitute by far the greatest portion of every society, certainly no system of policy can be recommended which has any tendency to diminish their hard-earned comforts. The experience of all ages has shown that a needy starving populace lose a just sense of their dignity and rights as men, and become depraved and enslaved. It is in vain to expect industry where it does not meet with a suitable reward; men will not submit to privations and labour, but in the hope of securing corresponding comforts.

Wages of Labour in 1770 and 1811.

According to Mr Young, to whose meritorious exertions we are indebted for much valuable and accurate information respecting political and rural economy, the mean price of agricultural labour in 1767, 1768, and 1770, was about 7s. 6d. *per* week, or 1s. 3d. *per* day. Mr Young further states the mean price of labour in 1810 and 1811 at 14s. 6d. *per* week, or 2s. 5d. *per* day, being a rise of nearly *cent. per cent.* on the former period. But he estimates the average rise on bread, meat, butter, and cheese, during the same interval, at 135 *per cent.*; and, consequently, wages were really higher in 1770 than in 1810, by the difference, or 35 *per cent.* Since 1813 the price of corn has fallen, but it is still double its price in 1770; and the average price of labour being now *less* than its then price, the situation of the independent poor is evidently altered, very much indeed to the worse.

It may perhaps be thought, that this fact contradicts the arguments by which we have endeavoured to establish the ultimate equality of prices and wages. But the increased price of commodities in this country during the war, was prevented from having its full effect in raising wages, by the operation of the POOR LAWS. Labourers were not deterred from marrying, as they knew that a fund was by law set aside for their support; and as they were certain, that, if the wages of labour would not suffice to rear a family, the deficiency would be made up by the parish. The comparative cheapness of labour has not, therefore, redounded, in the smallest degree, to the advantage of the employers of workmen. What they have saved as wages, they have paid as poor rates: And, as Mr Birkbeck has justly observed, the expence of labour in England is so much the greater, as it always costs more to maintain a pauper than to preserve an industrious man from poverty.

If, therefore, a bounty on exportation, or restrictions on importation, raise the exchangeable value, or the real price of corn, they will also raise the rate of wages. But, as the exchangeable value of manufactured commodities is not enhanced by a rise in the price of labour, it is evident, that the profits of stock, and the power of accumulating capital, must be diminished proportionably to the fictitious increase in the price of corn.

Effects of a Bounty on the Exportation of Raw Produce.

By extending the market for corn, when a bounty is first granted, the money price of raw produce is raised, and agricultural profits being elevated above

* A *few* of the following paragraphs are taken from an *Essay on the Question of Reducing the Interest of the National Debt*, written by the author of this article.

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the general level, there is an influx of capital from other departments, until they are again reduced. Thus far a bounty accomplishes its object, and gives at least a temporary stimulus to cultivation. If the newly employed capital rendered the same returns as the capital previously invested in raising corn, its real price would not be increased. But, as we have already observed, this cannot be the case long. Discoveries in agriculture may, for a while, prevent recourse being had to poor soils, but the constant increase of population will, in the end, force their cultivation. Now, the bounty has, in this respect, precisely the same effects as an increase of population. Both extend the demand for corn; and as, by this extension of the demand, we are at length forced to employ inferior machinery, or worse land, in order to raise the additional supplies, their value must be augmented.

Thus, if the prices of corn in Britain and Spain were nearly on a level, no exportation from the one to the other would take place. But if, when prices are in this situation, a bounty, say of 10s. *per* quarter, is granted by our government, corn would be immediately poured from England into Spain. Limits would, it is true, be soon set to this exportation and importation. The competition which takes place among exporters, as among every other class of traders, prevents their realizing more than the common and ordinary profits of stock, and hence grain would be exported from England to Spain, not with the expectation of realizing the whole of the bounty as profits, but with the view merely of securing the ordinary rate of profits on the capital employed in its transfer. A rise of prices, though not to the whole extent of the bounty, would therefore be immediately felt in this country, and a corresponding fall in Spain. Nor would this rise and fall of price be temporary. Corn would be permanently reduced in Spain, because the unusual cheapness of the foreign supplies would throw the poorest lands out of tillage; and it would be permanently raised in England, because the increased demand would stimulate the bringing of them under cultivation. A bounty, to the extent we have supposed, would perhaps depress prices 5s. *per* quarter in Spain, and raise them as much in Britain. To the Spanish nation it would be extremely advantageous, as it would enable them to purchase the most indispensable necessary of life at so much less than they could otherwise have done; in Britain, however, its effects would be directly opposite. A few more of our heaths and of our bogs would indeed be cultivated, but every class of persons in the kingdom, landlords alone excepted, would find it more difficult to procure food than before. The higher price of our corn, supposing it not to raise wages and diminish the profits of stock, which it would most unquestionably do, would obviously be of no advantage, and could not enrich the public, since it would in the end be exactly apportioned to the greater difficulty experienced in raising the additional quantity.

Every bounty is objectionable as producing an unnatural and fictitious distribution of the national capital; but a bounty on any manufactured commodity would not increase the quantity of labour necessary to its production, and, of course, would not raise its exchangeable value. In this respect, a bounty which has for its object to stimulate the raising of raw produce, is the most impolitic of any, inasmuch as it not only occasions a faulty distribution of capital, but also raises the cost of production, and, consequently, the real price of the articles produced.

The argument that Dr Smith has brought forward against granting a bounty is, therefore, untenable. The nature of things has not, as this great political economist imagined, stamped upon corn a real and unalterable value. The variations in its exchangeable value, including the effect of scarcity, and of extraordinarily luxuriant crops, though somewhat slow, are extremely perceptible at distant periods. The wheat which is raised at an immense expence from a worthless bog or morass, must surely have a greater value than that which, in an earlier stage of society, was raised almost spontaneously from rich alluvial lands. "It is natural," as Dr Smith has himself observed, "that what is usually the produce of two days' or two hours' labour, should be worth double of what is usually the produce of one day's or one hour's labour."

Bounty advantageous to Landlords.

"If good land existed in a quantity much more abundant than the production of food for an increasing population required, or if capital could be indefinitely employed without a diminished return on the old land, there could be no rise of rent; for rent invariably proceeds from the employment of an additional quantity of labour, with a proportionally less return." (Ricardo, *Principles of Political Economy*, p. 58.) Now, as bounties force us to have recourse to poor soils, and, consequently, diminish the productive power of fresh capital when applied to land, they must powerfully contribute to raise rent, and are, therefore, essentially beneficial to the landlords. To every other class of society, however, their effects are diametrically opposite. They are not merely burdened with the tax necessary to pay the bounty, and compelled to pay an additional price for their most indispensable necessaries, but the returns derived from capital are universally diminished. Farmers may, indeed, derive, during the currency of their leases, some advantage from a bounty, but it cannot be permanent. An increase in the cost of raising raw produce reduces the profits of agricultural as well as of every other stock. At the expiration of the farmer's lease his rent is raised, and he will be obliged to employ an additional number of labourers, and to pay them higher wages, while the rise in the price of his produce, as it can only be proportioned to the *rise of his rent*, or to the *additional number* of his labourers, will not compensate him for the rise in the rate of wages.

In as far, therefore, as bounties on exportation, or restrictions on the importation of corn, tend to raise its real price, or to prevent it from falling, they must also tend to diminish the general profits of stock, or to prevent their rising to what they would otherwise be, if no restrictions on importation existed.

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[Bo]unties [ha]ve a ten[den]cy to [for]ce Capital [ab]road.

But bounties in every case, and restrictions on importation where, as in Britain, they are effectual, not only tend to lessen the profits of stock, and to check the accumulation of capital, but they stimulate its transference to other countries. The love of country, the thousand ties of society and friendship, the ignorance of foreign languages, and the desire of having one's funds employed under their own inspection, will, no doubt, in many cases, induce capitalists to put up with a less rate of profit in their own, than they might receive by employing their funds in other countries. But the love of country has its limits. The love of gain is a no less powerful and constantly operating principle, and if capitalists are once assured that their stock can be laid out with equal security, and with considerably greater advantage in foreign states, a transference to a greater or less degree will unquestionably take place.

In the fifth edition of his *Essay on Population* (Vol. II. p. 246), Mr Malthus has dwelt at considerable length on the superior advantages enjoyed by a manufacturing country possessing great resources in land. He conceives, that such a country "would go on increasing in riches and strength, although surrounded by Bishop Berkeley's wall of brass." When manufacturing capital became redundant, and manufactured commodities too cheap, it would have no occasion to wait for the increasing raw produce of its neighbours. Its own redundant manufacturing capital would be transferred to land; and, on the same principle, when the price of raw produce fell too low, the capital employed in raising it would be consigned to manufactures. In this way, the national prosperity might, in Mr Malthus's opinion, be indefinitely prolonged.

If this able apologist of the restrictive system had extended this reasoning to the world at large, or at least to the commercial part of it, it would have been quite unexceptionable. But unless this particular country were *actually* surrounded by a wall of brass, capital would be withdrawn from it as soon as the increase of population had forced the cultivation of poorer soils than those in its immediate vicinity, or as soon as the real price of its raw produce had become comparatively high. Mr Malthus would readily admit, that no capitalist would rest satisfied with a less rate of profit in Devonshire, and would not continue to pay his labourers at a higher rate in that county, than in Yorkshire; but would affirm, with every other economist, that either the profits of stock must be increased, and the rate of wages reduced in Devonshire, or that a transference of capital would take place. And if he had recollected, that the laws which regulate the distribution of capital, between different provinces of the same kingdom, are the same with those which ultimately regulate its distribution among *different* and *independent* kingdoms, he could not have failed to perceive the extreme erroneousness of his conclusions, when applied to the case of a nation having any intercourse with its neighbours

This is the worst view that can be taken of the system of bounties and restrictions. To establish their impolicy, it is sufficient to show, that they necessarily check the *accumulation* or the increase of that fund, which can alone support labour and set it in motion, and by whose extent, the extent of the industry of the country must always be regulated. But if they do not merely check the accumulation of capital, but also force it abroad, we must be satisfied that they are among the very worst expedients to which, in order to secure some temporary advantage, or to remedy some temporary difficulty, a short-sighted policy can have recourse.

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Bounties have no Tendency to reduce the real Price of Corn by causing a Glut of the Market.

It has, however, been contended, that although the first effect of the bounty is to raise prices, yet that, by attracting an unusually great capital to land, it ultimately causes a glut of the market, and a fall of price. That this statement may to a certain extent be consistent with fact, and that a glut of the market, sufficient to cause a *temporary* depression of prices, may be produced by a bounty, we do not mean to deny; but such depression cannot last for any length of time, unless the real price of corn, that is to say, unless the labour necessary for its production, has also been diminished.

When an unusual demand has been at any time experienced for corn, and when capital is in consequence moving from manufactures to land, whether there shall be subsequently any permanent rise or fall of price, depends entirely on the circumstance of equal quantities of this newly employed capital being less or more productive, than the capital previously engaged in agriculture. This fresh capital cannot, however, be more productive, except from an improvement in the manner of working land, or from a saving of labour, which it is evident might equally take place without any bounty, and cannot be occasioned by it; and if it is expended, unaccompanied by any such improvement, it must either raise prices, or be in a great measure lost to the proprietors; for if the poorest soils in tillage do not yield the ordinary rate of profit, their cultivation must be abandoned.

In reference to the idea of a bounty glutting the home market, it may be observed, that that circumstance will very seldom happen, except in seasons when there is an extraordinarily luxuriant crop, and of course very low prices, in the country in which the grain exported by means of the bounty is usually sold. If Great Britain were *regularly* in the habit of exporting corn, either by a bounty or otherwise, to Spain, the average prices of both kingdoms would ere long become nearly stationary, at a rate such, that the cost of a quarter of wheat in Spain would exceed that of a quarter in England, by the cost of transporting it from the one to the other, including in that cost the profits of the capital employed in the carrying trade, insurance, &c. If such, however, was the case in ordinary years, it would be very different when there was any great diversity in the crops. When prices suddenly fell in Spain, exportation from England would as suddenly cease, and would not be again renewed until the fall in this country, caused by the cessation of the foreign demand, had been as great as in Spain. A nation which exports corn, is liable to fluctuations

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of price, not merely from the state of its own harvests, but also from those of its customers, and inasmuch as a bounty gives a factitious extension to exportation, it must also tend to render prices less steady.

Bounties have a tendency to increase fluctuations in the Price of Raw Produce.

But supposing the accuracy of this statement to be admitted, it may still be contended, that a nation which exports an extra quantity of corn by means of a bounty, has, at least, a greater resource in years of scarcity than a nation in a different situation. This idea, however, though extremely plausible, and to a certain extent correct, is, in the main, fallacious. If the deficiency of the crop did not exceed the ordinary quantity of corn exported, there would not certainly be any considerable rise of price, but if the deficiency exceeds that quantity, the situation of an exporting country must evidently be a great deal worse than that of a regularly importing one. In the latter, a slight rise of prices would induce a much greater importation, but in an exporting country, prices must not only be raised by the whole cost of the carriage from foreign ports, but by an additional sum, sufficient to determine importation into new channels.

Thus, a deficiency of the crop in Poland, which did not exceed the quantity of corn ordinarily exported from that country, would not have any material effect on prices; but, in order to cause an importation to make up for a deficiency of a greater extent, prices would have to rise, not merely higher than ordinary, but decidedly higher than the prices of those countries to which Poland had previously been in the habit of exporting.

Again, in seasons when there is a luxuriant crop in a country exporting by means of a bounty, it operates with double effect, and very little of the surplus is stored up to answer the home consumption in case of future exigencies. By forcing exportation, it hinders, as Dr Smith has observed, the plenty of one year from relieving the distresses of another, and therefore occasions, in years of scarcity, a greater importation than would otherwise have been necessary.

These conclusions do not depend on theory only. If we compare the prices from 1688 to 1766, the period of the operation of the bounty, and when the exports almost always exceeded the imports, with the prices of the period from 1765 to 1792, when the corn trade enjoyed a tolerable degree of freedom, and when importation and exportation were regulated nearly by the state of the supply and the demand, we shall find that prices varied a great deal more in the former period than in the latter. Keeping out of view the years in which the coin was degraded or its value fluctuating, in 1724 the price of the Winchester quarter of middling wheat was 32s. 10¾d. and in the following year it had risen to 43s. 1¾d.; in 1727 it fell to 37s. 4d. and, in 1728, it rose to 48s. 6d. The average price of 1740 and 1741 was 43s. 4d. and of 1743 and 1744 only 22s. 1d. a fall of almost *cent. per cent.* And, again, in 1754 and 1755, the average price was 30s. 5d. and in 1756, 1757, and 1758, it was as high as 46s. 8d. The greatest difference of price from 1711 to 1765, is that between the price of 1744, or 22s. 1d. and that of 1757, or 53s. 4d. amounting to no less than 148 *per cent.* On the other hand, the lowest price of the period from 1765 to 1792, is that of 1779, or 36s. 2d. and the highest that of 1773, or 59s. 2d. a difference of about 86 *per cent.* So much for the bounty steadying prices.

Inquiry whether Restrictions on Importation afford any security for obtaining an independent and ample Supply of Corn.

We hope we have now said enough to show the impolicy and pernicious tendency of the bounty. With our present comparatively high prices, we are indeed secured against its operation, should it be attempted again to renew it, as nothing but the granting an extremely large bounty, or, what is just the same thing, the imposing an extremely heavy tax on the country, could render our corn, in ordinary years, sufficiently cheap for the foreign market. The few following remarks shall, therefore, be directed solely to the propriety of *restricting importation.* And as we have already shown that the restrictive system, whenever it prevents purchasing in the cheapest market, and thereby fictitiously keeps up the price of corn, must, as well as the bounty, be exposed to the fundamental objection of diminishing the profits of capital and forcing it abroad; we shall now content ourselves with adverting to the security which the restrictive system is supposed to afford, of furnishing an independent and ample supply of provisions.

In the *first* place, it may be observed, that where one nation has been, for a series of years, in the habit of importing corn from another, it must have exported some more acceptable produce as an equivalent. The farmers of the corn growing country will, after this commerce is established, calculate as much upon the demand of the importing country, as on that of their own citizens. They will cultivate an additional quantity of land, raise larger crops, and consequently pay higher rents, solely beeause they are assured of this vent for their produce. The benefits of this intercourse are, therefore, reciprocal, and the corn growers, as much as the corn buyers, are interested in a continuance of the traffic. and would suffer as much by its cessation. "When we consider," says Mr Ricardo, "the value of even a few weeks consumption of corn in England, no interruption could be given to the export trade, if the Continent supplied us with any considerable quantity of corn, without the most extensively ruinous commercial distress,—distress which no sovereign, or combination of sovereigns, would be willing to inflict on their people; and, though willing, it would be a measure, to which, probably, no people would submit. It was the endeavour of Bonaparte to prevent the exportation of the raw produce of Russia, more than any other cause, which produced the astonishing efforts of the people of that country against the most powerful force, perhaps, ever assembled to subjugate a nation." (*Essay on the Profits of Stock*, p. 29.)

But, when a nation adopts a policy like that on which we are now acting, and refuses to admit any foreign corn, except when the home price reaches a height indicating scarcity, she must then, it is obvious, contend in a market to which no corn has been brought, with a view to answer her demand. The difficulties we have experienced in importing have

been greatly exaggerated; but they result, in fact, from the nature of our own policy respecting it. Perpetually fluctuating between bounties, restrictions, and prohibitions, no foreign country can ever calculate on our continuing to import their corn. We may buy a million of quarters to-day, but we shall, perhaps, buy no more for a couple of twelvemonths. If our demand was steady, if we regularly imported, additional supplies would be raised for our market; foreign rents would be raised, and not merely farmers, but landlords, would be interested in procuring us whatever quantity of corn we might require. But, in the present state of our corn trade, we only enter the foreign market as strangers. Our orders may be expected, but they cannot be reckoned on; and hence, whatever supplies we may procure, being withdrawn from the *ordinary stock*, foreign prices are speedily raised, exportation checked, and the home price allowed to reach an excessive height.

Most foreign states have indeed fixed a statutory price at which exportation shall always cease. But this price is much higher than the average; and although our corn trade were unrestricted, the importations into this country would not have much effect in raising prices abroad, as a greater production would *universally* take place; and foreign powers, becoming sensible of the advantages of a perfectly free trade, would soon repeal this limitation.

When a merely temporary liberty is granted to import, the operations and the enterprise of merchants are alike cramped. They cannot order corn from *distant* countries, lest the price should have fallen before it arrives, and the ports be shut. They are compelled to have recourse to countries in our immediate vicinity; their orders must be given on the spur of the moment; and all that consideration and combination, necessary to ensure the success of every complex transaction, are unavoidably excluded.

The corn law of 1815 has indeed given liberty at any time to import and warehouse foreign grain duty free, to be again re-exported, or used for home consumption when the price reaches 80s.; but this liberty does not seem to be of much consequence. Corn is at once a bulky and a perishable commodity, and no capitalist would choose to employ his funds in importing it, unless there was a strong probability, that prices would very soon attain the limit when it might be sold. Corn will at all times be stored up for a market such as that of Amsterdam, because it may there be disposed of at the pleasure of the holder, and its sale is not regulated by any contingent circumstance. In this country, the case is very different. An unforeseen change of weather will often check the rise of prices, at the very time a further rise was confidently expected; and even the warehousing of any considerable quantity of foreign grain, would of itself have a similar, though a much less effect. By giving no freedom to mercantile operations, and by preventing the importer from disposing of his commodity when he thinks proper, this system, in ordinary years, must put an end to the warehousing trade altogether. "Never," says an intelligent writer, "could there have been a greater inducement to warehouse than in the past year (1816). The season was unpropitious from the beginning, and all Europe seemed likely to suffer with ourselves, and yet not only was this warehousing carried to a very small extent, but our wheat was sent out of the country when it could have been procured for less than 50s. the quarter."

In the *second* place, the wider the surface from which a country derives its supplies of food, the less will it be exposed to fluctuations of price, arising from favourable or unfavourable seasons. A general failure of the crops of an extensive kingdom is a calamity that but seldom occurs. The weather that is unfavourable to vegetation in one species of soil is frequently advantageous to it in another. If moist clayey lands suffer from a wet summer, the crops are rendered more luxuriant in dry rocky districts. The excess of produce in one province compensates for its deficiency in another; and, except in anomalous cases, the total supply is nearly the same. But, if this be true of a single nation, it is *always* true in reference to the world at large. No one instance of universal scarcity blackens the history of mankind; but it is constantly found, that when the crops of one country fail, plenty reigns in some other quarter. A freedom of trade is alone wanted to guarantee a country like Britain, abounding in all the varied products of industry, in merchandise suited to the wants of every society, from the possibility of a scarcity. The nations of the earth are not condemned to throw the dice to determine which of them shall submit to famine. There is always abundance of food in the world. To enjoy a constant plenty, we have only to lay aside our prohibitions and restrictions, and to cease to counteract the benevolent wisdom of Providence.

The case of Holland strongly corroborates the truth of all we have stated. In the days of her greatest prosperity, she was chiefly fed with imported corn, and the prices there were extremely moderate; and, what is of infinite consequence, were steadier than in any country of Europe. Even during the convulsions of the last twenty years, and when her former commercial connections had been almost all dissolved, prices fluctuated very little.

A nation circumstanced like Great Britain, with prices infinitely higher than in surrounding nations, and growing nearly its own average supplies of corn, cannot fail to experience a very great and sudden fall of price when the market is glutted by a more than ordinarily luxuriant crop. If a year of unusual abundance should chance to follow a year in which prices had been rather higher than ordinary, and when a considerable quantity of foreign grain had been engrossed into our disposable produce, it is almost certain we should experience a glut. There can, however, be no steady and continued exertion of agricultural industry, where prices are exposed to great revulsions. Agriculture can only flourish where they are steady, or where they are progressively advancing. It does not seem possible, however, to guard against such fluctuations under our present system. While it is persevered in, an unusually luxuriant crop will be nearly as prejudicial to the farmers, as a deficient one is injurious to the consum-

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ers. Before any part of our surplus produce can be exported to almost any foreign market, it must decline 30s. or 40s. *per* quarter below what has been reckoned its *growing* price, or 80s.

Error of Mr Malthus on the subject of the Corn Laws.

Perhaps the most imposing of all the arguments which Mr Malthus has urged against the policy of allowing an unrestricted corn trade, proceeds on the assumption, that ultimately every agricultural nation will manufacture for itself, and will cease purchasing from abroad. But surely Mr Malthus does not mean to insinuate, that, in the progress of society, there will be no interchange of manufactured commodities for raw produce carried on between different countries! It is evidently impossible such a state of things can ever be brought about until the cost of raising raw produce in all the different commercial countries of the world shall be the same. America may, and it is highly probable *will*, very soon manufacture cotton goods for her own consumption; but while the cost of raising wheat is less in that republic than in England, it will be exported to us in return for some species of our produce. Nothing but the having recourse to the enactments of the thirteenth and fourteenth centuries, and prohibiting exportation altogether, can possibly prevent corn being sold where its exchangeable value is greatest.

That the profits of stock are diminished by the accumulation of capital, is supposed in every part of Mr Malthus' observations on the corn laws. This opinion is, however, fundamentally erroneous. Commodities being, in every case, bought with commodities, their multiplication cannot occasion any fall of the exchangeable value of one another. If, under any given circumstances, ten pairs of gloves exchanged for ten pairs of stockings, and ten quarters of wheat for ten pairs of boots, they will, in the same circumstances, continue, *provided they are all increased in the same relative proportions*, to preserve precisely the same exchangeable value, one with another, to whatever extent their quantities may be augmented. Thus, supposing the capital engaged in the different branches of trade and industry, to be adjusted in such a manner, that, all things considered, every branch yielded nearly the same rate of profit, it is evident that any amount of additional capital which was invested in them all, according to the same ratio of distribution, would not sink the price of any one article;—each would sell for precisely the same sum it sold for before, and if wages remained stationary, the profits of stock would neither be increased nor diminished. If too much of one commodity, as of cotton for example, is manufactured, its relative value will fall, and the profits of the stock employed in the cotton trade will be reduced, but such an effect can only be temporary. Some other department must, at the same time, be understocked, and, yielding larger profits, will attract the surplus capital employed in the cotton manufacture. We have, therefore, no reason to be alarmed at the effects of competition in any department. The manufacture of one commodity opens up a market for the exchange, that is, for the *sale* of some other commodity, and no commercial nation has any thing to fear from the progress of its neighbours. What it has really to fear is, that the average profits of its capital do not fall lower than the average rate of profit in the surrounding nations. If this is the case, its future progress will be clogged and retarded, and it will ultimately languish and decline. Neither the skill, industry, and perseverance of artisans, nor the most improved machinery, can permanently bear up against a constantly diminishing rate of profits. And such a *comparative* diminution of profit, let it be recollected, *is always produced by a fictitious enhancement of the price of corn.*

Popular argument in defence of the Corn Laws.

The most popular defence of the corn laws, and the only additional one we shall notice, rests on the ground, that as exclusive advantages are granted to different manufactures, agriculture ought, in strict justice, to be placed in the same favoured situation. But it was long ago demonstrated, that it cannot possibly be the interest of any state to manufacture at home, what it might purchase cheaper abroad. If, therefore, any of our manufactures, as that of silk, could not exist if a free trade were allowed, it would be for the general advantage that they were given up, and the capital vested in them employed in some other species of industry. The manufacturers of Gloucestershire, in their excellent resolutions against the late corn bill, expressed, in the strongest manner, their acquiescence in the doctrine of a free trade, and stated their perfect willingness to sacrifice any exclusive privileges they might enjoy, to the attaining that desirable object. It is, indeed, beyond all question, that a free trade would be very much for the advantage of those manufactures, part of which are at present exported. The fall that would then take place in the price of provisions and of labour, would much more than compensate any disadvantage the woollen manufacturers might experience, from a rise in the raw material; and in the cotton manufacture, the advantages would not be counterbalanced in the slightest degree.

"Because," says Mr Ricardo, referring to this argument, "the cost of production, and, therefore, the prices of various manufactured commodities, are raised by one error in legislation, the country has been called upon, on the plea of justice, quietly to submit to fresh exactions. Because we all pay an additional price for our linen, muslin, and cottons, it is thought just that we should pay also an additional price for our corn. Because, in the general distribution of the labour of the world, we have prevented the greatest amount of productions from being obtained by that labour in manufactured commodities; we should further punish ourselves by diminishing the productive powers of the general labour in the supply of raw produce. It would be much wiser to acknowledge the errors which a mistaken policy has induced us to adopt, and immediately to commence a gradual recurrence to the sound principles of an universal free trade." (*Principles of Political Economy, &c.* p. 444.)

The fact that, in ordinary years, the price of wheat at Dantzic scarcely ever exceeds 32s. and that its medium price in France and the Netherlands is below 40s. renders it certain, that if the late corn law had not been enacted, a considerable portion of the capital which has been expended in

manuring and cultivating inferior lands, in the period from 1800 to 1814, would have been rendered comparatively unproductive. This, however, is the *whole* extent of the loss that would have been experienced. The rent of the superior and yet cultivated land would have no doubt been reduced also; but its *produce*, and consequently the general wealth, would not, on that account, have been in the least diminished. Hard, therefore, as the case may appear, it would certainly have been much better that the fixed capital which could not have been withdrawn from poor soils had been sacrificed, than that the profits of every kind of stock in the kingdom, and the real wealth of all the other classes, should have been permanently reduced, in order to save a few landlords and farmers from the consequences of their own improvident speculations. It was not contended when the steam-engine, or when Sir R. Arkwright's cotton-mill was introduced, that they should not be employed, because the old clumsy machinery would thereby be superseded, and the capital vested in it lost. No such ridiculous opinion as this was ever entertained; but in what respect would it have been more absurd, than to persist in raising produce from a poor soil at an immense expence, when we might purchase plentiful supplies, and at a much cheaper rate, elsewhere? Why should not the best machinery be employed in raising corn as well as in spinning cotton? If an expenditure of L. 1000 would suffice to manufacture cottons or hardware at Glasgow or Birmingham, that would exchange for 400 or 500 quarters of Polish or American corn; and if the same sum, applied directly to the raising of corn, would not in this country yield more than 250 or 300 quarters; what folly can be greater than to continue such a comparatively disadvantageous production, and not to buy corn from foreigners with our manufactured goods? If private interests are not, in such cases, to give way to the general good, the improvement of society must at once come to a close, and mere sluggish routine must take the place of genius and invention. "Certainly," says Mr Malthus, who is by far the ablest defender of the restrictive system, "the legislature has nothing to do with securing to any class of its subjects a particular rate of profits in their different trades. *This is not the province of a Government;* and it is unfortunate that any language should have been used which may convey such an impression, and make people believe that their rulers ought to listen to the accounts of their gains and losses."

The unparaleled weight of our taxation, and the comparatively high wages of labour in this country, furnish no apology for the restrictive system. Taxation equally affects every part of the community, and does not fall heavier on the agriculturists than on any of the other classes. If this was not really the case, if every tax did not in the end fall entirely on the *consumers*, and on the different employers of workmen, what would be the situation of the French cultivators, who pay as "*contribution fonciere*" about one-fourth part of the produce of the soil directly to the state? Instead of being weakened, the power of the country to bear the oppressive weight of its burdens, would certainly be increased by the abolition of the corn laws. We should at least purchase food cheaper after the ports had been thrown open than at present; and surely that circumstance would enable us to make good our other payments with less difficulty. The high rate of wages, in as far as it is not ascribable to taxation, is, as we have already shown, an effect of our restrictive system; and its reduction would be one of the happiest consequences of a free trade.

It should never be forgotten, that restrictions on importation and high prices can only be of service to the landlords (for the farmers have, in fact, an opposite interest in the matter), where the consumers are rich enough to pay the high prices. If, however, we have been successful in showing that every enhancement of the price of corn lessens the accumulation of capital; and, stimulating its transfer abroad, necessarily diminishes that very fund which supports labourers, and, consequently, consumers, it must be obvious, that this system aims a deadly blow at the real prosperity of agriculture itself, as well as of every other species of industry. Whatever advantage the landlords may derive from the corn laws, can only be fleeting and illusory. It must arise from the corresponding depression and suffering of those classes, with whose welfare their own is intimately and inseparably connected. It is precisely the same with the relief a patient derives from a medicine which expels a curable, to leave an incurable disease in its room.

At the time when the late corn law was enacted, the revulsion and derangement, which must always attend a sudden fall of prices, were nearly over. Rents were generally reduced,—a considerable portion of the inferior lands had been sown down with grass seeds,—and wages were already on the decline. To have thrown the ports open would, in these circumstances, have been attended with very little inconvenience. Occurrences, beyond the reach of control, had paved the way for the introduction of a liberal system of policy, and it must ever be lamented that the opportunity was not embraced. If we shall, at any future period, think of retracing our steps, in order to give time to withdraw capital from the cultivation of poor soils, and to invest it in more lucrative employments, a gradually diminishing scale of duties may be adopted. The price at which foreign grain should be admitted duty free, may be made to decrease from 80s. its present limit, by 4s. or 5s. *per* quarter annually, till it reaches 50s., when the ports could safely be thrown open, and the restrictive system be for ever abolished.

When this happy event shall have taken place, it will be no longer necessary to force nature. The capital and enterprise of the country will be turned into those departments of industry in which our physical situation, national character, or political institutions, fit us to excel. The corn of Poland, and the raw cotton of Carolina, will be exchanged for the wares of Birmingham, and the muslins of Glasgow. The genuine commercial spirit, that which permanently secures the prosperity of nations, is altogether inconsistent with the dark and shallow policy of monopoly. The nations of the earth are like provinces of the same kingdom,—a free and unfettered intercourse is alike productive of general and of local advantage.

Present State of the Corn Trade.

III. Present State of the Corn Trade.

Quantity of Corn produced and consumed in Great Britain and Ireland.

Respecting the *present* state of the corn trade, as to consumption and supply, it is not easy to arrive at any perfectly satisfactory conclusions. On referring to the tables of export and import, annexed to this article, it will be seen, that, in 1811, the total value of the corn exported to foreign countries from Great Britain and Ireland amounted to L. 1,518,152, and of foreign corn imported to L. 1,103,165; and in 1812 the exports amounted to L. 1,559,737, and the imports to L. 1,232,027. In both these years, therefore, we raised more corn than was sufficient for home consumption; but, as the greater part of the excess of exports was sent to the peninsula as provision for British troops, we can only consider the growth of corn in the united kingdom to have then been commensurate with the total demand.

The *paper* prices of English wheat in 1811 and 1812 were 94s. and 125s. respectively; the bullion prices for the same period being 74s. and 98s., or 86s. on a medium. The prices of 1809 and 1810 were about as high; and, as farmers did not then realize any unusual profits, it may be concluded, that such a supply cannot, in ordinary years—without some decided improvement in agriculture, or without such a change in the political circumstances of the country, as will admit the poorest lands under tillage to be cultivated at a cheaper rate,—be obtained from our own soil at less than 80s. *per* quarter. Whether, however, the demand for corn has continued the same as in 1811 and 1812; for certainly it has not increased; or whether it has diminished, so that any considerable quantity of poor land has been thrown out of cultivation, and the exchangeable value of raw produce reduced, are questions which we have as yet no accurate data to determine.

It is extremely difficult to form any tolerably correct conclusions respecting the quantity of corn raised in an extensive kingdom, from calculations founded on the number of acres in tillage, and on the average produce *per* acre. No accurate estimate can possibly be framed of the extent of the lands under cultivation. It is perpetually changing from year to year; and the amount of produce varies not only with the differences in the seasons, but also with every improvement of agriculture. This method, therefore, has been very generally abandoned, and economists now attempt to estimate the growth of corn by its *consumption*. But, although this is certainly the preferable mode, still the conclusions to which it leads are necessarily very loose. The consumption varies considerably from one year to another, according as the power of the consumers to make purchases happens to be greater or less. But, supposing this power to remain the same, the average quantity of corn consumed by each person, and the species, can only be ascertained by approximation. Mr Charles Smith bestowed a very great deal of attention on this important investigation (*Tracts on the Corn Trade*); and, as his estimate of our aggregate produce forms the groundwork of almost all those which have been subsequently framed, it deserves particular attention. Having taken the population of England and Wales, in 1765, at 6,000,000, Mr Smith reckoned the consumers of each kind of grain, the quantity consumed by each individual, and hence the whole consumed by man, as follows:

Mr C. Smith's Estimate.

Estimated Population of England and Wales.		Average Consumption of each Person.	Consumed by Man. *Quarters.*
3,750,000	consumers	of wheat, at 1 qr. each	3,750,000
739,000	ditto	of barley, at $1\frac{3}{8}$ ditto	1,016,125
888,000	ditto	of rye, at $1\frac{1}{8}$ ditto	999,000
623,000	ditto	of oats, at $2\frac{7}{8}$ ditto	1,791,225
	Consumed by man,	-	7,556,350
In addition to this Mr Smith estimated the wheat distilled, made into starch, &c.			90,000
Barley used in malting, &c.		- -	3,417,000
Rye for hogs, &c.		- -	31,000
Oats for horses, &c.		- - -	2,461,500
Total of home consumption,		-	13,555,850
Add excess of exports over imports,			398,624
			13,954,474
Add seed, *one tenth*,		- -	1,395,447
Total growth of all kinds of grain in England and Wales in 1765,			15,349,921

This estimate, it will be observed, does not include either Scotland or Ireland, and later inquiries have rendered it probable that Mr Smith had underrated the population of England and Wales by nearly one million. The allowance for seed is also too small.

Mr Chalmers's Estimate.

Mr Chalmers, availing himself of the information respecting the subsistence of the people, furnished under the population act of 1800, estimated the total consumption of all the different kinds of grain in Great Britain at that epoch at 27,185,300 quarters, whereof wheat constituted 7,676,100 quarters: The crops of 1800 and of 1801 being unusually deficient, the importation in these years was proportionably great; but excluding these scarcities, the total average excess of all sorts of grain imported from Ireland and foreign countries into Great Britain over the exports, had previously amounted to about one million of quarters, which, deducted from 27,185,300, leaves 26,185,300, to which, if we add *one-eighth* as seed, we shall have 29,458,462 quarters as the average growth of Great Britain in 1800.

Although the population of Ireland has not been exactly ascertained, the authorities adduced by Messrs Newenham and Wakefield will not permit us to estimate it at less than *five* millions: The greatest portion of its inhabitants are, it is true, supported by the potatoe, and seldom or never taste bread; but we shall probably be within the mark if we estimate the number of those fed by the various kinds of corn at two millions, and the average quantity consumed by each individual at two quarters: This would give 4,000,000 of quarters as the total consumption of Ireland; which, being added to Mr Chalmers's estimate of the consumption of Great Bri-

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tain, gives 31,000,000 of quarters as the consumption of the whole empire.

Colquhoun's Estimate.

The population has, however, increased very considerably since 1800, and both Mr Western and Dr Colquhoun concur in estimating the average consumption of the whole empire in 1812 and 1814, at about 35 millions of quarters.

The following is Dr Colquhoun's estimate:

SPECIES OF GRAIN.	Estimated Average of the Population of Great Britain and Ireland.	Each Person averaged.	Consumed by Man.	Consumed by Animals.	Used in Beer and Spirits.	Used in various Manufactures.	Total of Quarters.
		Quarters.	*Quarters.*	*Quarters.*	*Quarters.*	*Quarters.*	
Wheat, .	9,000,000	1	9,000,000			170,000	9,170,000
Barley, . .	1,500,000	$1\frac{1}{4}$	1,875,000	210,000	4,250,000		6,335,000
Oats, . .	4,500,000	$1\frac{1}{2}$ *	6,750,000	10,200,000			16,950,000
Rye, . .	500,000	$1\frac{1}{4}$	625,000	59,000		1,000	685,000
Beans and Pease,	500,000	1	500,000	1,360,000			1,860,000
Totals. .	16,000,000		18,750,000	11,829,000	4,250,000	171,000	35,000,000

Progressive Consumption.

	Wheat.	Other Grain.	Total.
	Quarters.	*Quarters.*	*Quarters.*
One year, -	9,170,000	25,830,000	35,000,000
Six months, -	4,585,000	12,915,000	17,500,000
Three months, -	2,292,500	6,457,000	8,750,000
Six weeks, -	1,146,250	3,228,750	4,350,000
One month, -	764,166	2,152,500	2,916,666
Two weeks, -	382,083	1,076,250	1,458,333
One week, -	191,041	538,125	729,166
One day. -	27,291	76,875	104,166

As the exports in 1812 rather exceeded the imports, if we add *one eighth* as seed to Dr Colquhoun's estimate of the consumption at that period, we shall have about *forty* millions of quarters, as the total quantity of the different kinds of grain produced in Great Britain and Ireland.

Inquiry into the State of the Foreign Corn Trade.

The deficit in our home supplies of corn has been chiefly made up by importations from Prussia, and the other countries on the Baltic, and from America. In Prussia the corn trade is not regulated by any fixed principles, and the duties on exportation are continually varying. They are sure to be increased when there is any very unusual foreign demand; and in 1800 and 1801, when we imported immense quantities of corn from Dantzic, Koningsberg, &c. they must have yielded a very large revenue.

Poland.

The following table of the export of wheat from Dantzic, the principal corn market in the north of Europe, to England and other countries, from 1793 to 1803, both inclusive, is extracted from Oddy's *European Commerce*, p. 263:

	To England in Lasts.	To other parts.	Total.
1793, -	9,541 -	5,963 -	15,414
1794, -	6,244 -	12,529 -	18,773
1795, -	4,283 -	9,491 -	13,774
1796, -	20,407 -	6,474 -	26,881
1797, -	17,496 -	6,398 -	23,894
1798, -	18,357 -	7,991 -	26,348
1799, -	16,713 -	8,311 -	25,024
1800, -	37,202 -	3,661 -	40,863
1801, -	33,748 -	3,855 -	37,603
1802, -	27,028 -	25,388 -	52,416
1803, -	11,725 -	22,424 -	34,149

The Dantzic *last* is equal to about $10\frac{1}{2}$ Winchester quarters.

The extreme irregularity of the foreign demand, coupled with the variation of the duties on exportation, causes a very great fluctuation in the prices of corn at Dantzic. In Mr Oddy's opinion, the Poles can afford to sell their wheat for about 32s. *per* quarter, and their rye, which is a principal article of export, for about 19s. When, however, there is any extraordinary demand, or when it is understood that the crops either in Britain or Spain, the chief competitors in the Dantzic market, are considerably deficient, prices rise much higher.

The price of Russian wheat, exported from the ports on the Baltic, is generally lower than that of Dantzic. At Archangel, according to Mr Oddy's account, its mean price was, for the *fifteen* years previous to 1805, only about 26s. the quarter.

Russia.

Mr Oddy has given the following estimate of the total value of all the different kinds of grain, exported from the Russian Empire in 1802:

* This is certainly too small an allowance: It ought, at least, to have been *two* quarters.

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	Roubles.
Wheat, - -	4,055,907
Rye, - -	5,604,422
Barley, - -	1,004,144
Oats, - -	206,056
Other corn, - -	99,754
Wheat and rye flour, -	157,809
Spirits made from native corn,	368,153
Total value in roubles,	11,496,245

America.

The following is the British Customhouse statement of the quantity of wheat and flour imported into Great Britain from the United States, from 1803 to 1812, both inclusive:

	Wheat Quarters.	Flour Cwts.
1803, -	22,995 -	301,474
1804, -	——— -	14,907
1805, -	12 -	47,044
1806, -	8,987 -	243,587
1807, -	108,596 -	493,910
1808, -	8,925 -	13,691
1809, -	36,537 -	471,101
1810, -	34,829 -	210,210
1811, -	10,716 -	25,533
1812, -	180 -	37,161

The following is the American Custom-house statement of the total quantity of wheat and wheat flour exported from the United States, from 1801 to 1814, both inclusive, with their aggregate value in dollars.

	Wheat. *Bushels.*	Flour. *Barrels.*	Value of both. *Dollars.*
1801 -	239,929 -	1,102,444 -	———
1802 -	280,281 -	1,156,248 -	———
1803 -	686,415 -	1,311,853 -	9,310,000
1804 -	127,024 -	810,008 -	7,100,000
1805 -	18,041 -	777,513 -	8,325,000
1806 -	86,784 -	782,724 -	6,867,000
1807 -	766,814 -	1,249,819 -	10,753,000
1808 -	87,330 -	263,813 -	1,936,000
1809 -	393,889 -	846,247 -	5,944,000
1810 -	325,924 -	798,431 -	6,846,000
1811 -	216,833 -	1,445,012 -	14,662,000
1812 -	53,832 -	1,443,492 -	13,687,000
1813 -	288,535 -	1,260,943 -	13,591,000
1814 -		193,274 -	1,734,000

The *general* average price of wheat *per* bushel in the United States, in different years, has been as under:—

	Doll.	Cents.		Doll.	Cents.
1785, -	0	60	1808, -	1	25
1790, -	0	75	1809, -	1	25
1795, -	1	20	1810, -	1	50
1800, -	2	0	1811, -	1	75
1805, -	1	80	1812, -	1	94
1806, -	1	33	1813, -	1	75*
1807, -	1	25			

Corn Trade. France.

In 1787, a year of a fair average crop, M. Arnould estimated the value of the grain exported from France at 6,559,000 franks, and of that imported at 8,116,000 franks. Since that period the agriculture of that country has been very much improved; but as the population has also been augmented, we may perhaps conclude, that France now raises about as much grain as is necessary for her own consumption. If, however, a free corn trade were established between this country and France, we should, even under these circumstances, be able to import very considerable quantities of corn. There is always an excess of produce in the northern provinces of France, ready for the foreign market; for the southern provinces, where the crops are deficient, are more easily supplied by importations from Italy, Barbary, Odessa, &c.

The following is a table of the price of the septier of the best wheat, *blè de tete*, weighing 240 lbs. mark the septier, at the Rosoy, or Paris market, for 146 years, ending with 1788:

		Liv.	So.	Den.
From 1643 to	1652 -	35	14	1
1653	1662 -	32	12	2
1663	1672 -	23	6	11
1673	1682 -	25	13	8
1683	1692 -	22	0	4
1693	1702 -	31	16	1
1703	1712 -	23	17	1
1713	1715 -	33	1	6
1716	1725 -	17	10	9
1726	1736 -	16	19	4
1736	1745 -	18	15	7
1746	1755 -	18	10	11
1756	1765 -	17	9	1
1766	1775 -	28	7	9
1776	1785 -	22	4	7
	1786 -	20	12	6
	1787 -	22	2	6
	1788 -	24	0	0

General average of the 146 years, 24 liv. 1 so. 4 den.

The Revolution, by distracting the attention of the cultivators, rendered the crops deficient; and, since that era, there have been a few seasons of scarcity, but there has not been any general rise of prices. In 1800, the mean price of wheat in the Paris market was exactly 14 fr. 19 cents. the hectolitre, equal to 21 fr. 28 cents. the septier. In the following year, the mean price of the septier, in the eleven departments, forming the district of the north, which comprises Paris, reached 29 fr. 40 cents; but the price was then reckoned very high.—(*Statistique Elementaire de la France*, p. 291.) Peuchet gives us a table of the price of wheat in the different departments of France, in the month of February 1805, and the mean price of the hectolitre, in the above-mentioned district, is 16 fr. 55 cents., equal to 24 fr. 60 cents. the septier. (*Idem*, p. 456.) From

* The prices of the *five* first mentioned years are taken from a Statistical Manual of the United States, published in 1806; and those of the last eight are taken from Mr Pitkin's late valuable work on the Commerce of that Republic.

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this period up to 1812, when there was a slight deficiency in the crops, prices continued to *decline*. In July 1814, Mr Birkbeck states the price of wheat in the market of Rouen, one of the most populous manufacturing towns in France, as being equal to 34s. our quarter.—(*Tour in France*, p. 12.) And, in October of that year, Mr Malthus states, that the average price of the hectolitre in 14 different markets of Normandy, was 16 fr. 21 cents, being 24 fr. 31 cents the septier, or 36s. 8d. the Winchester quarter; and it is of importance to observe, that this average was taken *after* riots had occurred both at Havre and Dieppe on account of the rise of prices, and the quantity of wheat exported. Mr Malthus adds, that, according to all the information he had obtained, average prices had not been higher in France during the last *ten* years. (*Grounds of an Opinion, &c.* p. 13.)

The law of 1814, authorizing the export of corn from France, ordered that it should cease whenever the home price reached to about 48s. or 49s. the Winchester quarter; and as the object of this law was to conciliate the landed interest, and to encourage and promote cultivation, it is pretty certain, that 48s. or 49s. had been reckoned rather a high price. But in 1764, exportation free of duty was allowed till the home price reached 30 livres the septier, or 48s. the Winchester quarter; a fact which, of itself, sufficiently shows that, *the ordinary price of corn, previous to* 1814, *was not higher than it had been previous to* 1764.

The Winchester quarter is equal to $1\frac{35}{41}$ of a septier, or to $1\frac{7}{8}$ very nearly; and the franc is equal to 1 liv. 0 so. 3. den.

The mean of the different estimates framed by Vauban, Quesnay, Expilly, Lavoisier, and Arthur Young, gives 61,519,672 septiers (*Statistique Elementaire de la France*, p. 290), or 32,810,000 quarters very nearly, as the total average growth of the different kinds of grain in France. But this estimate is unquestionably a great deal too low. The peasantry of France eat much more bread than the peasantry of Great Britain or Ireland; and although there is not a proportionable consumption for horses, distilleries, &c. in that kingdom, we may reckon this excess as at least partially balanced by the other. But, independent of this circumstance, if Dr Colquhoun's estimate of 18,750,000 quarters, as the quantity of the different kinds of corn consumed by man in this empire, which has only about 12,000,000 of inhabitants who can be considered as consumers, be not very much overrated, the consumption of France, with a population of about 27,000 000, who are all chiefly supported on corn, cannot be taken at less than 42,190,000 quarters; and, adding *one-eighth* for seed, the total growth of corn in that country, will be about 47,500,000 quarters. Even this estimate, we are persuaded, is still too low.

Spain.

Notwithstanding the extraordinary fertility of Spain, the various abuses under which that country labours, combined with the want of all freedom in its internal corn trade, and with the numberless restrictions imposed on exportation, prevents its producing, in ordinary years, an adequate supply for home consumption. Catalonia, Valencia, &c. draw a considerable part of their supplies from Barbary; while Andalusia, Biscay, &c. occasionally enter into competition with us in the markets of the North, and in those of the United States.

The following is a statement of the medium price of the *fanega* of wheat, in the month of May each year, at the market of Medina de Rio Seco, in Leon, from 1793 to 1804, both inclusive:

	Reals Vellon.		Reals Vellon.
1793 -	$32\frac{1}{2}$	1799 -	$36\frac{1}{2}$
1794 -	$39\frac{3}{4}$	1800 -	29
1795 -	$44\frac{1}{4}$	1801 -	43
1796 -	$28\frac{1}{4}$	1802 -	$65\frac{3}{4}$
1797 -	$37\frac{1}{4}$	1803 -	$61\frac{3}{4}$
1798 -	$62\frac{3}{4}$	1804	155

The Castile *fanega* is used at Medina de Rio Seco; and 100 *fanegas Castellanas* make 152 Winchester bushels. The real vellon is equal to $\frac{1}{20}$ of a dollar. (*App. Bullion Report*, No. 32.)

Bourgoing informs us, that the year 1804 was anomalous in the annals of Spain—contagious diseases, the inclemency of the heavens, and famine, laid waste the whole country. Above *nine millions* of *fanegas* of wheat were imported from abroad, and the price of corn rose to *six* or *seven* times its mean price (Bourgoing, Tom. II. p. 162.) Extraordinary fluctuations in the price of corn are, however, very frequent in Spain. In 1652, wheat sold in Seville at 15s. 3d. a bushel, and, in 1657, so low as 1s. 4d. (Townsend's *Travels in Spain*, II. p. 220.) Owing to the shackles on the internal corn trade, there is often a very great difference in the prices of corn in the different provinces.

Italy, in ordinary years, does not, at present, export much grain; but Sicily, under an enlightened government, might easily be made to produce immense supplies.

The extreme fertility of the Russian territory bordering on the Black Sea, has, since the free navigation of the Dardanelles was secured to that power, led to a very great exportation of grain from Odessa, Taganrock, &c. This exportation may be indefinitely extended, and supplies to any amount may be derived from this newly opened market.

The following tables, extracted from *official* documents, will, it is presumed, contain all the additional facts necessary to be known respecting the British and Irish corn trade, up to a very late period.

TABLES respecting the British and Irish Corn Trade.

No. I.—ACCOUNT of the Prices of Middling or Mealing Wheat *per* Quarter at Windsor Market, as ascertained by the Audit-Books of Eton College.

YEARS.	Prices of Wheat at Windsor, 9 Gallons to the Bushel.			Prices of Wheat reduced to the Winchester Bushel of 8 Gallons.			Average of 10 Years, according to the Winchester Bushel of 8 Gallons.		
	£.	s.	d.	£.	s.	d.	£.	s.	d.
1646	2	8	0	2	2	8			
1647	3	13	8	3	5	5¾			
1648	4	5	0	3	15	6¾			
1649	4	0	0	3	11	1¼			
1650	3	16	8	3	8	1¾			
1651	3	13	4	3	5	2¼			
1652	2	9	6	2	4	0			
1653	1	15	6	1	11	6¾			
1654	1	6	0	1	3	1¼			
1655	1	13	4	1	9	7½	2	11	7¾
1656	2	3	0	1	18	2¾			
1657	2	6	8	2	1	5¾			
1658	3	5	0	2	17	9¼			
1659	3	6	0	2	18	8			
1660	2	16	6	2	10	2¾			
1661	3	10	0	3	2	2¾			
1662	3	14	0	3	5	9¼			
1663	2	17	0	2	10	8			
1664	2	0	6	1	16	0			
1665	2	9	4	2	3	10¼	2	10	5¾
1666	1	16	0	1	12	0			
1667	1	16	0	1	12	0			
1668	2	0	0	1	15	6¾			
1669	2	4	4	1	19	5			
1670	2	1	8	1	17	0½			
1671	2	2	0	1	17	4			
1672	2	1	0	1	16	5½			
1673	2	6	8	2	1	5¾			
1674	3	8	8	3	1	0½			
1675	3	4	8	2	17	5¾	2	0	11¾
1676	1	18	0	1	13	9¼			
1677	2	2	0	1	17	4			
1678	2	19	0	2	12	5¼			
1679	3	0	0	2	13	4			
1680	2	5	0	2	0	0			
1681	2	6	8	2	1	5¾			
1682	2	4	0	1	19	1¼			
1683	2	0	0	1	15	6¾			
1684	2	4	0	1	19	1¼			
1685	2	6	8	2	1	5¾	2	1	4¼
1686	1	14	0	1	10	2¾			
1687	1	5	2	1	2	4½			
1688	2	6	0	2	0	10¾			
1689	1	10	0	1	6	8			
1690	1	14	8	1	10	9¾			
1691	1	14	0	1	10	2¾			
1692	2	6	8	2	1	5¾			
1693	3	7	8	3	0	1¼			
1694	3	4	0	2	16	10¼			
1695	2	13	0	2	7	1¼	1	19	6¾
1696	3	11	0	3	3	1¼			
1697	3	0	0	2	13	4			
1698	3	8	4	3	0	9			
1699	3	4	0	2	16	10¾			
1700	2	0	0	1	15	6¾			
1701	1	17	8	1	13	5¾			
1702	1	9	6	1	6	2¾			
1703	1	16	0	1	12	0			
1704	2	6	6	2	1	4			
1705	1	10	0	1	6	8	2	2	11
1706	1	6	0	1	3	1¼			
1707	1	8	6	1	5	4			
1708	2	1	6	1	16	10¾			
1709	3	18	6	3	9	9¼			
1710	3	18	0	3	9	4			
1711	2	14	0	2	8	0			
1712	2	6	4	2	1	2¼			
1713	2	11	0	2	5	4			
1714	2	10	4	2	4	9			
1715	2	3	0	1	18	2¾	2	4	2¼
1716	2	8	0	2	2	8			
1717	2	5	8	2	0	7¼			
1718	1	18	10	1	14	6¼			
1719	1	15	0	1	11	1¼			
1720	1	17	0	1	12	10¾			
1721	1	17	6	1	13	4			
1722	1	16	0	1	12	0			
1723	1	14	8	1	10	10¾			
1724	1	17	0	1	12	10¾			
1725	2	8	6	2	3	1¼	1	15	4¾
1726	2	6	0	2	0	10¼			
1727	2	2	0	1	17	4			
1728	2	14	6	2	8	5½			
1729	2	6	10	2	1	7½			
1730	1	16	6	1	12	5¼			
1731	1	12	10	1	9	2¼			
1732	1	6	8	1	3	8½			
1733	1	8	4	1	5	2¼			
1734	1	18	10	1	14	6¼			
1735	2	3	0	1	18	2¾	1	15	2
1736	2	0	4	1	15	10¼			
1737	1	18	0	1	13	9¼			
1738	1	15	6	1	11	6¾			
1739	1	18	6	1	14	2¾			
1740	2	10	8	2	5	1½			
1741	2	6	8	2	1	5¾			
1742	1	14	0	1	10	2¾			
1743	1	4	10	1	2	1			
1744	1	4	10	1	2	1			
1745	1	7	6	1	4	5¼	1	12	1
1746	1	19	0	1	14	8			
1747	1	14	10	1	10	11½			
1748	1	17	0	1	12	10¾			
1749	1	17	0	1	12	10¾			
1750	1	12	6	1	8	10¾			
1751	1	18	6	1	14	2¾			
1752	2	1	10	1	17	2¼			
1753	2	4	8	1	19	8½			
1754	1	14	8	1	10	9¾			
1755	1	13	10	1	10	1	1	1	2¾

Corn Trade.

YEARS.	Prices of Wheat at Windsor, 9 Gallons to the Bushel.	Prices of Wheat reduced to the Winchester Bushel of 8 Gallons.	Average of 10 Years according to the Winchester Bushel of 8 Gallons.
	£. s. d.	£. s. d.	£. s. d.
1756	2 5 2	2 0 $1\frac{3}{4}$	
1757	3 0 0	2 13 4	
1758	2 10 0	2 4 $5\frac{1}{4}$	
1759	1 19 8	1 15 3	
1760	1 16 6	1 12 $5\frac{1}{4}$	
1761	1 10 2	1 6 $9\frac{3}{4}$	
1762	1 19 0	1 14 8	
1763	2 0 8	1 16 $1\frac{3}{4}$	
1764	2 6 8	2 1 $5\frac{3}{4}$	
1765	2 14 0	2 8 0	1 19 $3\frac{1}{4}$
1766	2 8 6	2 3 $1\frac{1}{4}$	
1767	3 4 6	2 17 4	
1768	3 0 6	2 13 $9\frac{1}{4}$	
1769	2 5 8	2 0 7	
1770	2 9 0	2 3 $6\frac{3}{4}$	
1771	2 17 0	2 10 8	
1772	3 6 0	2 18 8	
1773	3 6 6	2 19 $1\frac{1}{4}$	
1774	3 2 0	2 15 $1\frac{1}{4}$	
1775	2 17 8	2 11 $3\frac{1}{4}$	2 11 $3\frac{3}{4}$
1776	2 8 0	2 2 8	
1777	2 15 0	2 8 $10\frac{3}{4}$	
1778	2 9 6	2 4 0	
1779	2 0 8	1 16 $1\frac{3}{4}$	
1780	2 8 6	2 3 $1\frac{1}{4}$	
1781	2 19 0	2 12 $5\frac{1}{4}$	
1782	3 0 6	2 13 $9\frac{1}{4}$	
1783	3 1 0	2 14 $2\frac{3}{4}$	
1784	3 0 6	2 13 $9\frac{1}{4}$	

YEARS.	Prices of Wheat at Windsor, 9 Gallons to the Bushel.	Prices of Wheat reduced to the Winchester Bushel of 8 Gallons.	Average of 10 Years according to the Winchester Bushel of 8 Gallons.
	£. s. d.	£. s. d.	£. s. d.
1785	2 14 0	2 8 0	2 7 $8\frac{1}{2}$
1786	2 7 6	2 2 $2\frac{3}{4}$	
1787	2 11 6	2 5 $9\frac{3}{4}$	
1788	2 15 6	2 9 4	
1789	3 3 2	2 16 $1\frac{3}{4}$	
1790	3 3 2	2 16 $1\frac{3}{4}$	
1791	2 15 6	2 9 4	
1792*		2 13 0	
1793	* From this	2 15 8	
1794	year, inclu-	2 14 0	
1795	sive, the Ac-	4 1 6	2 14 $3\frac{3}{4}$
1796	count at E-	4 0 2	
1797	ton College	3 2 0	
1798	has been	2 14 0	
1799	kept accord-	3 15 8	
1800	ing to the	6 7 0	
1801	bushel of 8	6 8 6	
1802	gallons, un-	3 7 2	
1803	der the pro-	3 0 0	
1804	vision of the	3 9 6	
1805	act of 31st	4 8 0	4 1 $2\frac{1}{2}$
1806	Geo. III. c.	4 3 0	
1807	30, sect. 82.	3 18 0	
1808		3 19 2	
1809		5 6 0	
1810		5 12 0	
1811		5 8 0	Average of
1812		6 8 0	8 Years †
1813		6 0 0	5 1 $9\frac{1}{4}$

† The Eton Account of Prices commenced in 1595; the accuracy of the returns in the first years cannot, however, be so implicitly relied on, as those we have here quoted.—Bishop Fleetwood and Sir F. M. Eden have collected, with great industry, almost all the existing information respecting the state of prices in England during the last *six hundred* years.

No. II.—ACCOUNT of the Average Prices of British Corn *per* Quarter, and of Oatmeal *per* Boll, of 140 lbs. Avoirdupois, in England and Wales, since 1792, as ascertained by the Receiver of Corn Returns:

YEARS.	Wheat.	Rye.	Barley.	Oats.	Beans.	Peas.	Oatmeal.
	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.
1792	2 2 11	1 10 8	1 6 9	0 17 10	1 11 7	1 12 8	1 13 0
1793	2 8 11	1 15 11	1 11 9	1 1 3	1 17 8	1 18 4	1 18 11
1794	2 11 8	1 17 9	1 12 10	1 2 0	2 2 6	2 6 8	1 18 1
1795	3 14 2	2 8 5	1 17 8	1 4 9	2 6 8	2 13 4	2 3 6
1796	3 17 1	2 7 0	1 15 7	1 1 9	1 18 10	2 3 6	2 2 9
1797	2 13 1	1 11 11	1 7 9	0 16 9	1 7 6	1 13 5	1 13 10
1798	2 10 3	1 10 11	1 9 1	0 19 10	1 10 1	1 13 11	1 16 8
1799	3 7 6	2 3 9	1 16 0	1 7 7	2 4 7	2 5 2	2 5 0
1800	5 13 7	3 16 11	3 0 0	1 19 10	3 9 3	3 7 5	3 12 1
1801	5 18 3	3 19 9	3 7 9	1 16 6	3 2 8	3 7 8	3 10 0
1802	3 7 5	2 3 3	1 13 1	1 0 7	1 16 4	1 19 6	1 19 3
1803	2 16 6	1 16 11	1 4 10	1 1 3	1 14 8	1 18 6	1 18 7
1804	3 0 1	1 17 1	1 10 4	1 3 9	1 18 7	2 0 10	2 0 8
1805	4 7 10	2 14 4	2 4 8	1 8 0	2 7 5	2 8 4	2 3 8
1806	3 19 0	2 7 4	1 18 6	1 5 8	2 3 9	2 3 6	2 4 2
1807	3 13 3	2 7 6	1 18 4	1 8 1	2 7 3	2 15 11	2 4 3
1808	3 19 0	2 12 4	2 2 1	1 13 8	3 0 8	3 6 7	2 8 9

Corn Trade.

YEARS.	Wheat.	Rye.	Barley.	Oats.	Beans.	Pease.	Oatmeal.
	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.
1809	4 15 7	3 0 9	2 7 3	1 12 8	3 0 9	3 0 2	2 11 4
1810	5 6 2	2 19 0	2 7 11	1 9 4	2 13 7	2 15 9	2 11 11
1811	4 14 6	2 9 11	2 1 10	1 7 11	2 7 10	2 11 6	2 8 6
1812	6 5 5	3 15 11	3 6 6	2 4 0	3 12 8	3 13 7	2 9 8
1813	5 8 9	3 10 7	2 18 4	1 19 5	3 16 5	3 18 6	2 3 5
1814	3 14 0	2 4 6	1 17 4	1 6 6	2 6 7	2 10 0	1 13 0
1815	3 4 4	1 17 10	1 10 3	1 3 10	1 16 1	1 18 10	1 10 0
1816	3 15 10	2 3 2	1 13 5	1 3 6	1 18 4	1 18 4	1 8 4
1817	4 14 9	2 16 6	2 8 3	1 12 1	2 12 0	2 11 5	1 19 3

(Signed) WM. DOWDING, *Receiver of Corn Returns.*
London, 14th August 1818.

No. III.—ACCOUNT of the Average Prices of BRITISH CORN *per* Quarter, and of OATMEAL *per* Boll, of 140 lbs Avoirdupois, in SCOTLAND since 1792, as ascertained by the Receiver of Corn Returns:

YEARS.	Wheat.	Rye.	Barley.	Oats.	Beans.	Pease.	Oatmeal.
	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	L. s. d.
1792	1 19 4	1 4 11	1 3 1	0 16 6	1 7 1	1 6 10	0 14 6
1793	2 3 7	1 6 7	1 5 6	0 18 6	1 12 8	1 12 9	0 16 10
1794	2 5 4	1 7 5	1 5 0	0 18 10	1 12 5	1 12 7	0 16 11
1795	3 6 4	1 6 7	1 9 6	1 0 6	1 14 0	1 13 9	0 17 1
1796	3 11 5	1 10 9	1 9 11	1 2 0	1 18 2	1 17 9	0 19 6
1797	2 6 0	1 6 7	1 3 4	0 16 6	1 8 3	1 8 1	0 14 6
1798	2 3 5	1 6 9	1 2 3	0 17 7	1 9 8	1 10 1	0 15 9
1799	2 18 1	1 10 10	1 8 9	1 3 7	1 16 9	1 15 11	1 0 1
1800	4 11 2	2 18 3	2 11 4	2 2 5	3 13 7	3 14 11	1 18 9
1801	5 1 8	3 6 2	2 12 10	1 18 4	3 6 3	3 7 1	1 13 9
1802	3 4 6	1 13 10	1 9 6	0 19 5	1 13 3	1 13 2	0 16 10
1803	2 10 4	1 13 4	1 4 3	0 19 10	1 14 9	1 15 1	0 18 0
1804	2 13 3	1 18 8	1 7 4	1 2 3	1 16 1	1 15 9	0 19 2
1805	2 13 7	1 18 7	1 6 8	1 2 4	1 15 3	1 14 6	0 19 3
1806	3 16 4	1 14 4	1 17 0	1 4 0	1 16 5	1 16 2	1 0 0
1807	3 6 5	1 15 6	1 11 6	1 4 3	1 17 0	1 16 8	1 0 4
1808	3 6 7	1 19 0	1 14 7	1 7 1	2 7 9	2 7 1	1 2 11
1809	3 11 7	2 13 5	2 1 0	1 13 10	3 1 7	3 2 8	1 9 0
1810	4 5 6	2 11 6	2 0 1	1 12 1	2 15 8	2 16 6	1 8 7
1811	3 18 10	2 1 10	2 0 0	1 8 5	2 9 8	2 10 5	1 4 6
1812	3 11 9	2 0 10	1 16 6	1 4 6	2 1 7	2 2 2	1 1 0
1813	5 7 10	2 16 11	2 13 6	2 0 7	3 7 11	3 8 10	1 13 1
1814	4 16 2	3 6 6	2 12 8	1 17 9	3 2 10	3 4 6	1 12 4
1815	3 2 5	2 0 9	1 18 2	1 5 10	1 19 5	1 19 9	1 1 0
1816	2 13 6	1 19 2	1 7 8	1 2 9	1 13 2	1 13 0	0 18 6
1817	3 8 3	1 18 4	1 9 8	1 3 8	1 15 5	1 15 8	0 18 11

(Signed) WM. DOWDING, *Receiver of Corn Returns.*
London, 14th August 1818.

No. IV.—ACCOUNT of the Average Prices of IRISH WHEAT *per* Quarter since 1792.

1792	L.1 17 5	1803	L.2 9 4
1793	2 4 11	1804	2 18 0
1794	2 11 9	1805	3 9 2
1795	3 1 0	1806	3 7 7
1796	3 0 8	1807	3 7 9
1797	2 2 7	1808	3 16 7
1798	2 5 2	1809	3 18 2
1799	3 1 4	1810	3 18 5
1800	4 19 2	1811	3 10 5
1801	4 8 1	1812	5 8 3
1802	2 12 1		

No. V.—TOTAL VALUE, at the Average Market Prices, of all the CORN and GRAIN Imported into Ireland from *Foreign* Countries, from 1792 to 1812, both inclusive:

1792	L. 7,936	1803	L. 20,057
1793	2,904	1804	4,104
1174	58,862	1805	7,940
1795	912	1806	6,634
1796	4,531	1807	19,210
1797	21,015	1808	3,195
1798	5,036	1809	53,984
1799	27,046	1810	13,723
1800	320,092	1811	10,361
1801	383,819	1812	18,177
1802	12,701		

Corn Trade.

No. VI.—An ACCOUNT of the Quantity of WHEAT and WHEAT FLOUR Exported; and of FOREIGN WHEAT and WHEAT FLOUR Imported,—in the following Years:

YEARS.	Wheat and Flour Exported.	Foreign Wheat and Flour Imported.
	Quarters.	*Quarters.*
ENGLAND - 1697	14,699	400
1698	6,857	845
1699	557	486
1700	49,056	5
1701	98,324	1
1702	90,230	—
1703	166,615	50
1704	90,313	2
1705	96,185	—
1706	188,332	77
1707	74,155	—
1708	83,406	86
1709	169,680	1,552
1710	13,924	400
1711	76,949	—
1712	145,191	—
1713	176,227	—
1714	174,821	16
1715	166,490	—
1716	74,926	—
1717	22,954	—
1718	71,800	—
1719	127,762	20
1720	83,084	—
1721	81,633	—
1722	178,880	—
1723	157,720	—
1724	245,865	148
1725	204,413	12
1726	142,183	—
1727	30,315	—
1728	3,817	74,574
1729	18,993	40,315
1730	93,971	76
1731	130,025	4
1732	202,058	—
1733	427,199	7
1734	498,196	6
1735	153,343	9
1736	118,170	16
1737	461,602	32
1738	580,596	2
1739	279,542	5,423
1740	54,390	7,568
1741	45,417	40
1742	293,260	1
1743	371,431	2
1744	231,984	2
1745	324,839	6
1746	130,646	—
1747	266,907	—
1748	543,387	385
1749	629,049	382
1750	947,602	279
1751	661,416	3
1752	429,279	—
1753	299,609	—
1754	356,270	201
GT. BRITAIN 1755	237,466	—
1756	102,752	5
1757	11,545	141,562
1758	9,234	20,353
1759	227,641	162
1760	393,614	3
1761	441,956	—
1762	295,385	56
1763	429,538	72
1764	396,857	1
1765	167,126	104,547
1766	164,939	11,020
1767	5,071	497,905
1768	7,433	349,268
1769	49,892	4,378
1770	75,449	34
1771	10,089	2,510
1772	6,959	25,474
1773	7,637	56,857
1774	15,928	289,149
1775	91,037	560,988
1776	210,664	20,578
1777	87,686	233,323
1778	141,070	106,394
1779	222,261	5,039
1780	224,059	3,915
1781	103,021	159,866
1782	145,152	80,695
1783	51,943	584,183
1784	89,288	216,947
1785	132,685	110,863
1786	205,466	51,463
1787	120,536	59,339
1788	82,971	148,710
1789	140,014	112,656
1790	30,892	222,557
1791	70,626	469,056
1792	300,278	22,417
1793	76,869	490,398
1794	155,048	327,902
1795	18,839	313,793
1796	24,679	879,200
1797	54,525	461,767
1798	59,782	396,721
1799	39,362	463,185
1800	22,013	1,264,520
1801	28,406	1,424,766
1802	149,304	647,664
1803	76,580	373,725
1804	63,073	461,140
1805	77,955	920,834
1806	29,566	310,342
1807	24,365	400,759
1808	77,567	81,466
1809	31,278	448,487
1810	75,785	1,530,691
1811	97,765	292,038
1812	46,325	246,376

Corn Trade

No. VII.—ACCOUNT of the Quantity of WHEAT and WHEAT FLOUR, and of CORN, RICE, and all other kinds of Grain Imported into Great Britain from *Foreign* countries, from 1792 to 1812, both inclusive, with their Total Value at the Average Market Prices:

YEARS.	Wheat.	Wheat Flour.	Total Quantity Imported.			Total Value at the Average Market Price.
			Corn and Grain.	Meal and Flour.	Rice.	
	Quarters.	*Cwts.*	*Quarters.*	*Cwts.*	*Cwts.*	£.
1792	18,931	7,757	642,598	7,757	234,025	856,095
1793	415,376	211,588	1,088,781	211,588	193,680	2,021,993
1794	316,086	9,308	1,066,248	13,013	86,576	1,768,811
1795	274,522	86,726	463,939	124,329	145,500	1,461,622
1796	820,381	205,855	1,570,377	238,132	407,048	4,487,116
1797	420,414	2,769	789,824	2,785	118,241	1,455,722
1798	378,740	1,734	894,019	1,734	203,447	1,569,757
1799	430,274	61,584	653,934	64,234	93,570	1,765,840
1800	1,174,523	312,367	2,037,765	343,870	315,649	8,755,995
1801	1,186,237	833,016	2,087,614	1,123,714	310,609	10,149,098
1802	470,698	236,061	751,004	252,736	432,300	2,155,794
1803	224,055	309,409	507,484	309,569	113,999	1,164,592
1804	386,194	17,060	925,755	17,072	60,402	1,855,333
1805	821,164	54,539	1,165,272	54,566	78,925	3,754,831
1806	136,763	248,907	324,256	248,927	147,722	1,106,540
1807	215,776	504,209	667,899	504,213	97,733	1,878,521
1808	35,780	19,642	106,751	19,939	46,659	336,460
1809	245,774	497,314	631,236	498,747	356,218	2,705,496
1810	1,304,577	472,633	1,553,229	475,978	272,370	7,077,865
1811	179,645	31,215	265,613	32,581	124,802	1,092,804
1812	115,811	49,194	243,833	53,038	78,862	1,213,850

No. VIII.—ACCOUNT of the Quantity of OATS and OATMEAL, of WHEAT and WHEAT FLOUR, and of all the other kinds of Grain Imported into Great Britain from Ireland, from 1792 to 1812, both inclusive, with their Total Value at the Average Market Prices:

YEARS.	Oats.	Oatmeal.	Wheat.	Wheat Flour.	Total Quantity Imported.		Total Value at the Average Market Price.
					Corn and Grain.	Meal and Flour.	
	Quarters.	*Cwts.*	*Quarters.*	*Cwts.*	*Quarters.*	*Cwts.*	£.
1792	483,931	116,039	1,270	——	492,994	116,039	598,370
1793	269,465	36,250	13,974	2,080	291,066	38,330	391,460
1794	361,653	26,646	8,551	2,121	389,663	28,767	495,004
1795	335,920	30,304	13,408	3,796	351,312	34,100	526,803
1796	280,416	95,881	——	11	281,295	95,892	470,628
1797	289,253	71,304	36,489	14,257	338,597	85,561	464,234
1798	310,579	81,651	16,667	2,864	380,864	84,515	549,848
1799	324,857	54,135	14,773	1,898	341,344	56,033	600,920
1800	640	2,782	131	2,164	849	4,946	13,785
1801	366	14	——	1,834	366	1,848	3,804
1802	275,088	105,040	86,939	79,032	373,496	184,072	839,507
1803	230,917	55,695	48,228	45,638	295,065	101,333	525,860
1804	198,758	64,845	65,890	14,635	271,513	79,480	564,321
1805	186,144	26,969	78,692	18,884	284,370	45,853	721,304
1806	326,814	47,558	91,343	38,918	425,563	86,476	925,183
1807	307,957	31,702	38,784	7,487	371,043	39,293	687,996
1808	436,854	67,587	39,436	2,234	506,342	71,130	1,091,709
1809	782,622	64,899	57,680	10,301	857,947	75,200	1,732,155
1810	417,697	41,531	82,280	30,790	511,942	72,742	1,205,511
1811	207,255	23,080	93,062	36,444	306,397	59,524	836,926
1812	303,535	54,786	97,195	67,603	440,473	123,019	1,641,583

Corn Trade.

No. IX.—ACCOUNT of the Aggregate Quantity of CORN, and Grain of all sorts, Exported from Great Britain from 1792 to 1812, both inclusive, with their Total Value at the Average Market Prices:

YEARS.	Total Quantities Exported.			Total Value at the Average Market Price.
	Corn and Grain.	Meal and Flour.	Rice.	
	Quarters.	*Cwts.*	*Cwts.*	£.
1792	357,489	174,729	174,959	1,063,753
1793	79,430	115,740	96,172	361,053
1794	153,265	139,909	79,336	579,487
1795	17,643	66,444	25,809	149,393
1796	38,018	87,101	76,692	266,171
1797	72,916	121,720	69,730	310,909
1798	81,581	137,528	73,532	344,340
1799	88,538	85,395	44,626	365,607
1800	32,184	54,914	6.422	234,578
1801	28,617	94,814	20,947	297,094
1802	144,745	160,813	210,899	807.060
1803	114,006	105,233	57,163	393,560
1804	188,019	120,179	50,292	536,092
1805	94,884	86,714	41,734	505,102
1806	71,541	99,911	49,371	337,222
1807	49,553	89,677	30,810	259,892
1808	54,376	252,739	15,359	484,231
1809	37,987	100,061	28,738	298,669
1810	114,271	62,718	139,054	716,923
1811	218,537	94,313	83,698	893,469
1812	137,530	83,195	32,141	760,130

No. X.—ACCOUNT of the Quantity of CORN, and Grain of all sorts, Exported from Ireland to Great Britain, from 1792 to 1812, both inclusive, with their Total Value at the Average Market Prices:

YEARS.	Total Quantities Exported.			Total Value at the Average Market Price.
	Corn and Grain.	Meal and Flour.	Rice.	
	Barrels.	*Cwts.*	*Cwts.*	£.
1792	642,202	90,009	——	365,750
1793	572,857	20,507	——	385,099
1794	683,110	39,269	——	458,125
1795	157,058	33,418	468	129,165
1796	646,745	108,288	26	471,511
1797	673,401	90,312	826	453,529
1798	687,225	95,479	821	501,074
1799	156,100	25,719	180	131,245
1800	——	1,010	2,759	7,674
1801	——	254	——	394
1802	654,100	209,272	——	766,279
1803	519,042	119,877	209	549,176
1804	508,549	85,523	53	605,040
1805	487,306	54,467	293	638,020
1806	635,153	76,905	933	800,967
1807	844,618	49,777	——	829.933
1808	1,072,309	75,465	106	1,235,315
1809	1,462,364	105,431	3,256	1,591,559
1810	890,131	133,019	3,413	1 200,773
1811	702,864	120,931	1,744	1,092,916
1812	1,054,720	138,134	563	2,138,573

No. XI.—ACCOUNT of the *Total* Quantity of OATS and OATMEAL, of WHEAT and WHEAT FLOUR, and of all other kinds of Grain, Exported from Ireland to Great Britain and other Countries, from 1792 to 1812, both inclusive, with their Total Value at the Average Market Prices:

YEARS.	Oats.	Oatmeal.	Wheat.	Wheat Flour.	Total Quantity Exported.			Total Value at the Average Market Price.
					Corn and Grain.	Meal and Flour.	Rice.	
	Barrels.	*Cwts.*	*Barrels.*	*Cwts.*	*Barrels.*	*Cwts.*	*Cwts.*	£.
1792	637,277	96,552	92,788	34,156	732,835	130,724	256	493,649
1793	512,932	24,427	36,701	4,239	595,061	28,668	——	416,969
1794	644,504	36,576	31,231	5,411	683,856	41,988	122	460,619
1795	152,541	37,503	——	1,366	157,065	38,871	468	133,349
1796	648,596	112,464	15	2,562	648,636	115,026	152	505,725
1797	557,736	79,535	67,526	18,051	678,287	97,586	892	462,284
1798	594,972	93,148	46,325	5,602	695,459	98,757	1,116	511,906
1799	157,938	27,066	345	261	159,669	27,327	2,457	138,899
1800	——	640	——	1,157	——	1,797	2,759	8,915
1801	200	1,276	——	457	202	2,981	——	4,084
1802	475,066	108,189	168,937	91,759	665,328	215,522	140	782,308
1803	391,102	76,619	102,037	43,383	530,840	121,658	213	562,179
1804	372,780	67,233	153,088	21,593	550,625	88,826	53	681,208
1805	316,244	34,297	136,638	22,774	521,799	57,071	293	699,923
1806	461,700	43,451	153,214	37,350	641,610	80,805	992	814,698
1807	724,347	46,772	71,475	7,021	871,832	53,801	120	863,405
1808	935,850	72,088	79,509	8,060	1,081,621	80,160	106	1,252,468
1809	1,285,028	90,610	141,695	18,603	1,478,097	110,220	5,890	1,616,338
1810	756,254	57,299	194,621	91,469	1,032,469	149,131	3,548	1,429,725
1811	565,581	42,114	364,752	125,984	1,119,982	168,098	2,087	1,717,599
1812	824,883	45,818	339,094	127,526	1,397,469	173,344	594	2,938,180

Cornwall.

Situation and Boundaries.

CORNWALL is the most westerly county in England, and stretches also farthest to the south. It is bounded on all sides by the sea, except on the east, where it meets Devonshire in a few places, and is separated from it, for the most part, by the river Tamar. From this last boundary, its breadth is diminished till it terminates on the west at the Land's End, in west longitude 6°, and, on the south, at the Lizard Point, in north latitude 49° 57′ 30″, assuming somewhat of the form of a cornucopia; its boundaries, the Bristol Channel on the north, and the English Channel on the south, meeting in a point at the promontory on the west. It is situated in the diocese of Exeter, belongs to the western circuit, extends over 758,484 acres, or a little more than 1185 square miles, and contains nine hundreds, 201 parishes, twenty-three market towns, and, in 1811, 216,667 inhabitants, nearly 183 to the square mile, or about one individual for every three acres and a half. The waste lands are about one-fifth of the whole. The surface is very irregular, ascending and descending in rapid succession. The interior is high and generally unfertile, consisting for the most part of rugged heaths and moors; yet Brown Willy, the highest hill, is only 1368 feet above the level of the sea at low water. Some beautifully picturesque vallies intervene, richly diversified with corn, woods, coppices, orchards, rivulets, and verdant meadows. The stupendous rocks which form the great barriers against the ocean, particularly about the Land's End and the Lizard, are fitted to inspire the mind with the most sublime conceptions; while the remains of an early age, military, civil, and religious, dispersed over the county, present, in striking contrast, the small scale on which the works of man are conducted, and the instability of human affairs. Throughout the higher lands, the soil is a light black earth, intermixed with gravel, the detritus of the granite, or *growan*, as it is here called; a light loam, mixed with slaty matter, is the most prevalent on the gentle declivities and lower grounds. Clay is found in different places of various quality. One kind is made into bricks, which are in request for furnaces, and another is much valued when formed into moulds for casting metals. For nine months in the year, the wind blows from points between the west and south, bringing with it from the Atlantic vast bodies of clouds, which, being broken by the narrow ridge-like hills of the county, descend in frequent showers. Storms are more frequent and violent than in the inland parts of England, particularly from the north-west; but from this quarter the wind is generally dry and brings fair weather. The climate is healthy, and there are numerous instances of longevity. Snow seldom lies for a few days. The myrtle, the balm of Gilead, and many other tender plants and shrubs, live and thrive in the open air; yet the most hardy trees on the sea coast sustain much injury from the violence of the westerly wind, and the sea spray which it drives with great force before it. The only shrub which seems to bear the sea air is the tamarisk, which grows to the height of ten or twelve feet in seven years, in situations most exposed to the sea, forming an admirable shelter, and, as it bears cutting, might be useful also as a fence; yet it is destroyed by severe frosts. The cuttings by which it is propagated take root without difficulty. Till within these few years, the attempt to raise plantations was scarcely ever successful; but, latterly, the pineaster being first planted as a shelter to the more tender trees, their appearance is more promising. The principal rivers are the Tamar, the Lynher, the Looe, the Fawy, the Camel or Alan, and the Fal. The Tamar is the most considerable. It rises on the summit of a moor in the parish of Morvinstow, the most northern in the county, and, taking a southerly direction, falls, along with several tributary streams, into the spacious bason called the Hamoaze, and issuing thence between Mount Edgecumbe and the Devil's Point, unites with the waters of the Plym; and the conflux of these rivers with the sea forms the noble road for shipping named Plymouth Sound.

Extent. Surface. Soil. Climate. Rivers.

The landed property of Cornwall is very much divided, few estates producing a rent of more than L. 3000, exclusive of the underground revenues, which are continually fluctuating. What are called the Duchy lands are far more extensive. The income derived from them, and from the duty on the coinage of tin, are the only parts unalienated of the immense hereditary revenues which formerly constituted an independent provision for the heir-apparent to the Crown. This provision was originally made by Edward III. for his eldest son, Edward the Black Prince, whom he created Duke of Cornwall, with special limitation to the first begotten sons of him and his sons, Kings of England, for ever. The occupiers of these estates are lessees under the Duke of Cornwall, and generally purchase an interest in the land during three lives, the consideration being a fine paid at the time of the grant, and also a reserved rent during the lease. A lease for three lives is common on church-lands, and formerly was not unfrequent also on private estates. Leases at rack-rent seldom exceed fourteen years. The farms are, in general, very small, the rents, even in the most fertile parts, being only from L. 30 to L. 50, and, in the western and mining districts, they are chiefly cottage holdings. Agriculture, being but a subordinate concern here, is not generally pursued with much spirit and success; and the fines paid for their long leases, deprive the farmers of that capital which should be invested in the improvement of the soil from year to year. Their best cattle are of the North Devon breed, and much employed in labour. The native sheep of the county, now nearly extinct, was one of the worst descriptions in Britain. A great many different breeds have been introduced from other districts. The backs of horses or mules are used more frequently than carts or waggons as the means of transport. Barley, oats, and potatoes, are grown beyond the consumpt, though the course of cropping is generally most exhausting; but a large quantity of wheat or flour is imported for the mining districts. In the neighbourhood of Penzance, two crops of potatoes are commonly obtained every year. Sea-sand, sea-weed, and damaged pilchards, are used to a considerable extent as manure.

Duchy Lands. Leases. Agriculture.

Minerals.

Cornwall has long been distinguished by its mineral treasures, of which the most considerable are tin and copper. The strata in which these metals are found extend from the Land's End, in a direction

Cornwall. from west to east, to the Dartmoor Hills in Devonshire, and consist chiefly of granite and a variety of the grauwacke, here called *killas*. The chief seat of the mines now lies in the neighbourhood and to the westward of St Austel; from which place to the Land's End the principal mines are to be found, extending along the northern coast, and keeping a breadth of about seven miles. These metals are commonly found in veins or fissures called *lodes*, of which the sides or walls do not always consist of the same substance, nor are they equally hard; for, though one side of the fissure may be a dense stone, the other is sometimes as soft as clay. Many lesser veins branch from the great lodes like the boughs of a tree, and at last terminate in threads. The indications of a vein of metal are various, such as scattered fragments of ore, called *shodes*, and the metallic taste of springs. Many rich lodes have been discovered by working *drifts* across the county, in the directions of north and south. From the course of the metals being from west to east, the lode will thus be cut at right angles. See the article MINING in this *Supplement*.

Tin. *Tin*, the most important mineral of this county, is found collected and fixed, and also in a loose and dispersed form. In the former state, it is either in a lode, or a *floor* which is a horizontal layer of the ore; or interspersed in grains and small masses in the natural rock. The same lode that has continued perpendicular for several fathoms, is sometimes found to extend suddenly into a floor. In its dispersed form it is met with either in a pulverized state, in separate stones called *shodes*, or in a continued course of stones called a *stream*. These streams are of different breadths, seldom less than a fathom, and often scattered, though in different quantities, over the whole tract in which they are found. When several streams meet they frequently make a very rich floor. The principal stream work is at Carnon, between Truro and Penryn.

The most common state in which tin is found in this county is the calciform, the greater part of the ore being indurated or glass-like, and its most prevalent matrix is either an argillaceous or a silicious substance, or a stone composed of both, called, by the miners, *caple*. None of the calcareous genus ever appear contiguous to the ore, except the *fluors*. The oxides of iron and arsenic are those with which the tin is most frequently blended. When raised from the mine it is divided into as many shares or *doles* as there are lords and adventurers. Every mine possesses the privilege of having the ore distributed on the adjacent fields. It is generally pounded or stamped on the spot, and when it is small enough to pass through the holes of an iron grate fixed in one end of the box where the *lifters* work, it is carried by a small stream into pits, from which it is transferred into a large vat, washed, and rendered sufficiently clear for the smelting-house. The tin, when wrought into metal, is cast into blocks weighing from $2\frac{3}{4}$ cwt. to $3\frac{3}{4}$ cwt. each, which are not saleable till assayed by the proper officers, and stamped with the Duchy seal. This is

Tin Coinage. termed *coining* the tin. Since the reign of Henry VIII. the coinages have been held regularly four times annually, at Lady Day, Midsummer, Michaelmas, and Christmas, at the stannary towns of Launceston, Lostwithiel, Truro, and Helston, to which Penzance was added by Charles II. The annual produce of the tin mines is about 25,000 blocks, each worth ten guineas on an average. A duty of four shillings a hundred weight is paid to the Duke of Cornwall, on all the tin coined, which is said to amount to about L. 10,000 yearly.

Copper. *Copper ores* are found in great abundance and variety. Veins are frequently discovered in cliffs that are laid bare by the sea. The most encouraging indication of a rich ore, is an earthy ochreous stone, called *gossan*, which is of a reddish colour, and crumbles like the rust of iron. The ore does not lie at any particular depth; but it is a general rule, that, when copper is discovered in any fissure, the lode should be sunk upon, as it commonly proves best at some distance below the surface. When the metal has been properly refined, it is poured into oblong iron moulds, each containing about 150 lbs. weight. In the General View of the county, printed in 1794, the produce of all the copper mines is said to be about 40,000 tons of ore, yielding 4700 tons of copper, then worth L. 8 a ton.

Many other minerals have been found in this county; much capital and labour have been employed in working some of them, without their yielding any adequate return; yet the success has been in a few instances so great, that new mines are opened as fast as the old ones are abandoned. We can only mention some of the more important.

Lead, &c. *Lead* mines are not numerous; the kind of ore most frequently found is *galena*, or pure sulphuret of lead, which is met with both crystallized and in masses. The principal mines are Huel Pool and Huel Rose near Helston. *Gold* has been discovered, but not in such quantity as to warrant expensive operations to procure it. *Silver* is reported to have been obtained here in so large a quantity in the reigns of Edward I. and Edward III., as materially to aid the warlike enterprises of these monarchs, but recent searches have not been so successful. *Iron* ores; *Sulphuret of iron*, of the various colours of blue, green, purple, gold, silver, and copper, often intermixed with the copper lodes; *bismuth*, *zinc*, *antimony*, *cobalt*, *arsenic*, *manganese*, *wolfram*, *menachanite*, and *molybdena* or sulphuret of molybdenum, are all found here, most of them in considerable abundance. According to Phillips' map of the mines in 1800, there were wrought at that time 45 of copper, 28 of tin, 18 of copper and tin, two of lead, one of silver, one of lead and silver, one of copper and silver, one of copper and cobalt, one of tin and cobalt, and one of antimony.

Fossils. Among the other fossil substances of this county, those that deserve to be mentioned for their value are *slate*, of which there is an excellent quality wrought near Tintagel, in the north part of the county; a *freestone*, resembling the Portland and Bath stone, in the parishes of Carantoc and the lower St Colomb; and the celebrated *soap-rock*, between the Lizard and Mullion, used in the manufacture of porcelain, and rented by the proprietors of that establishment in Worcester. But the most important of these substances is what is called the

Cornwall. *China-stone*, found in the parish of St Stephen, near St Austel, which forms a principal ingredient in all the Staffordshire pottery. It is a decomposed granite, the felspar of which has lost the property of fusibility. At Truro it has been manufactured into retorts and crucibles. To these may be added the *Cornish diamonds*, supposed to be the finest in England, consisting of beautifully transparent quartz, crystallized in six-sided pyramids; and a curious production, called the *swimming stone*, found in a copper mine near Redruth, the cellular structure of which renders it lighter than water.

Pilchard Fishery. Of the fish which frequent the Cornish coast, the pilchard is the most abundant and valuable. In size and form it differs but little from the common herring. Immense shoals appear during the summer and autumn, the first generally arriving at the Land's End in the middle of July. The principal fisheries on the southern coast are in Mount's Bay, and thence eastward to Devonshire; and, on the northern side, at St Ives. The pilchards are caught in nets called *scans*, each of which is managed by three boats, containing from 17 to 24 men, the largest kind being 220 fathoms long, 16 fathoms deep in the middle, and 14 at each end. When brought on shore they are carried to storehouses or *cellars*, as they are termed, where the small and broken fish are picked out. They are then disposed in layers on the pavement of the cellar, salt being strewed between every layer. In this state they remain for about six weeks, after which they are taken up, washed, and placed in hogsheads, where, by means of a powerful lever, they are pressed so closely, as, when turned out, to appear in a compact state. By this process the oil is extracted, which runs out of the casks through holes made for the purpose: 48 hogsheads generally yield a ton of 252 gallons, the price of which, some years ago, was from L.24 to L.27. The fish then sold from 35s. to 42s. a hogshead (which contains about 3000), inclusive of a bounty of 8s. 6d. allowed on those for home consumpt, as well as exportation; the quantity of salt necessary for curing a hogshead is about 420 lbs. From 40,000 to 60,000 hogsheads are caught in a season. The number of people employed in the different processes is about 5000, and the capital engaged in the trade at least L.300,000. Nearly all that were exported used to be consigned to Italy. The *blower* or *finfish*, the *grampus*, the *porpoise* or *sea-hog*, the *blue shark*, the *sea-fox*, visit the coasts of this county. Among the flat fish is a most uncommon one named *the monk* or *angel* fish, the *turbot*, the *sea-adder*, and the singular fish called the *sun-fish*. *Mackarel* is caught in great plenty on the southern coast, also the *red mullet* and the *John Dory*; and *conger eels* of an extremely large size, weighing from 60 to 120 lbs. are met with near the shores. *Oysters* are in great abundance.

Representation. Cornwall possesses a greater number of Parliamentary boroughs than any other county in the kingdom, and sends to the House of Commons no less than 44 members, many of them from places extremely inconsiderable, both in wealth and population; in few of them is the number of voters above 50. A thousand militia are raised for the county, and as many more for the stanneries. The assizes are held alternately at Launceston and Bodmin. As there are scarcely any manufactures here, the poor rates, excepting in the mining districts, are not high, if compared with those of many other parts of the kingdom; from 2s. 6d. to 3s. in the pound may be about the usual rate; but in the mining districts, they are sometimes so high as 10s. or 12s. in the pound.

Cornwall ‖ Cornwallis.

Poor Rates.

Population. The following abstract is taken from the returns made under the population act of 1811:—

Inhabited houses - -	87,971
Families occupying them -	44,189
Houses building - -	441
——— uninhabited - -	1,400
Families employed in agriculture	17,465
——— in trade, manufactures, &c.	10,954
——— all other classes -	15,770
Males - - -	103,310
Females - - -	113,357
Total - - -	216,667
Population in 1801 - -	188,117
Increase from 1801 to 1811 -	28,550

For an account of the history of the county and its mines, the laws and privileges of the tinners, and other matters not noticed here, the reader is referred to the article CORNWALL in the *Encyclopædia*. See also Carew's *Survey*, last edition, 1769; Borlase's *Natural History of Cornwall*, 1758, and *Antiquities, Historical and Monumental*, 1769; *Beauties of England and Wales*, Vol. II.; *Transactions of the Geological Society*; and Worgan's *General View of the Agriculture of Cornwall*, 1811. (A.)

CORNWALLIS, CHARLES, the first Marquis, second Earl, and sixth Baron Cornwallis, was born on the 31st of December 1738, of an ancient and honourable family, which had been settled during many centuries in the county of Suffolk. He was educated at Eton school, and afterwards entered of St John's College, Cambridge, by the name and title of Lord Brome. Having exhibited an early partiality for the military profession, he entered into the army when about 17 or 18 years of age, and attained the rank of captain in Colonel Crawford's light infantry in 1758. Three years afterwards he accompanied the Marquis of Granby to the continent, in the capacity of *aid-de-camp*, and with the rank of major; and, in consequence of his good conduct, he was soon after promoted to be lieutenant-colonel of the twelfth regiment of foot. At this period he had also a seat in the House of Commons, as the representative of his patrimonial borough of Eye. Upon the demise of his father, who was the fifth peer of the family, in 1762, he, of course, vacated his seat in the House of Commons, and became a peer of Great Britain, under the title of Earl Cornwallis. In 1765, he was nominated one of the lords of the bed-chamber, and, about the same time, he was appointed *aid-de-camp* to his present Majesty, which gave him the rank of Colonel in the line. The favours conferred on him by the court, however, had not the effect of corrupting the natural integrity of his mind. He carefully distin-

Cornwallis. guished between his duties as a senator, and as a soldier; and, as a peer of Parliament, he displayed the independence of his character in several important questions, by voting against the measures of administration. From the very beginning, he showed himself inimical to those steps which led to the contest with the American colonies; and was one of four peers who joined Earl Camden, in opposing the bill for extending the legislative power of Great Britain to our Trans-Atlantic provinces. He also protested against the proceedings of Ministers, in the case of Mr Wilkes. In 1766, he was promoted to the command of the 33d regiment of foot; and two years afterwards (14th July 1768), he married Miss Jemima Tulikins Jones, daughter of the late James Jones, Esq.

But although Lord Cornwallis had uniformly and decidedly opposed those coercive measures, which produced the fatal contest with America, he did not hesitate to repair thither, in the service of his country, when his professional exertions were required. Accordingly, when his regiment was ordered for embarkation, although special leave of absence had been obtained for him from the King, he resolved to share the fatigues and dangers of foreign service, and took leave of his lady, who was so much affected by the separation, that she sunk under the weight of her grief into a premature grave.

Having proceeded to his destination, his Lordship took an active part in the subsequent campaigns. Soon after his arrival in America, he served, with the rank of Major General, under Sir William Howe, and distinguished himself as an able and enterprising partizan. In the month of November 1776, he landed on the New Jersey shore, and finding Fort Lee evacuated, he immediately penetrated into the country, and took possession of the province. His Lordship, however, soon discovered that this was a contest, in which the triumphs of skill, valour, and discipline, were not attended with the usual consequences of victory; and that the nature of the country, and the mode of warfare adopted by the provincial Generals, opposed many obstacles to a speedy and successful termination of hostilities. At the end of the campaign, he repaired to New York, with the view of embarking for England, in order that he might have an opportunity of explaining to the British Ministry the real situation of affairs; but having received information of the disasters at Trenton, he deferred his voyage, and returned to the Jerseys.

The first enterprise of Lord Cornwallis, in the campaign of 1777, was an attempt to surprise an American post in his neighbourhood, in which he partly succeeded. Soon after this, he received orders from General Howe to abandon the Jerseys; and in the month of July he embarked with the English Commander-in-Chief, on the expedition to the Chesapeak. In several of the subsequent events of this campaign, his Lordship was actively engaged. At the passage of the Brandy-wine river, he commanded a considerable body of troops; and after driving the enemy before him, he entered and took possession of Philadelphia, on the 24th of September 1777. From that period, he seems to have had little opportunity of signalizing himself, until the campaign of 1779–1780, when he embarked as Lieutenant-General, with Sir Henry Clinton, on the expedition to Carolina. At the siege of Charlestown, Lord Cornwallis performed eminent services, having attacked and dispersed a body of militia which was hastening to the relief of the place. On the surrender of the town, the command of the province of South Carolina, with about four thousand troops, devolved upon him. He was opposed by General Gates, who had previously distinguished himself in the actions with Burgoyne, and who was now appointed to the chief command of the provincial forces in South Carolina. Gates, having received intelligence of the situation of the royal troops, rapidly advanced towards Cambden, with the design of making an attack upon the British lines. Lord Cornwallis, however, having determined not to await the approach of the Americans, left his position, and marched against them with a greatly inferior force. The two armies met on the 16th of August, in a narrow place, where the colonial troops could not avail themselves of their superior numbers. The British General, perceiving the advantage which the ground afforded him, commenced the assault, and the action soon became general. The determined gallantry of the British troops, who charged with the bayonet, at length compelled the enemy to give way, and they were pursued nearly twenty miles from the field. Many of the colonial troops fell in this engagement; one thousand men were taken prisoners; and seven pieces of cannon, together with the greater part of the ammunition and stores of the provincial army, remained in possession of the British. But this success, brilliant as it was, produced no permanent advantage to the cause of the royalists, and was more than compensated by the misfortunes which ensued. In 1781, Lord Cornwallis having withdrawn, with the force under his command, into York-town, he was surrounded by a numerous American army, commanded by Washington; and finding all attempts to repel the besiegers, or to escape through their lines ineffectual, he was under the necessity of submitting to a capitulation, by which his whole army became prisoners of war.

Lord Cornwallis now returned to his native country. During the political contests which took place in 1782 and 1783, his Lordship was deprived of his situation as Constable of the Tower, which, however, was restored to him in 1784. For some years following, his talents were not called into exercise by any conspicuous public employment. But when the affairs of India began to assume a very critical aspect, he was selected as the person best qualified to fill the important situation of Governor-General; and he was, at the same time, invested with the order of the Garter. Soon after his arrival in India, the Company were involved in a war with the formidable sovereign of the Mysore, Tippoo Sultan, son of the famous Hyder Ally. The conduct of hostilities was at first entrusted to the Madras Government; but towards the end of the year 1790, the Governor-General assumed the command of the grand army, and took the field

in person. The events of this war having been fully detailed in the article INDIA in the *Encyclopædia*, it is unnecessary for us to recapitulate the narrative in this place. It is sufficient to observe, that, by a combination of vigour and prudence, the contest was brought to a successful termination in the course of two campaigns. Tippoo, beaten in the field, and forced to confine his efforts to the defence of his capital, was at length compelled by necessity to submit to such terms as the British commander chose to dictate, and to purchase peace by the sacrifice of half his dominions, and a large portion of treasure. The power of the Sultans of Mysore, the most formidable enemies of the British Government in India, was thus effectually undermined, and the train laid for its subsequent annihilation.

At the conclusion of the war in India, Lord Cornwallis returned to England. He was now (1792) created a Marquis; admitted a member of the Privy Council; and, in addition to his other appointments, he was nominated to the lucrative office of Master-General of the Ordnance, which gave him a seat in the cabinet. A few years afterwards, his talents were again required for the public service. Ireland being in a state of ferment,—harassed with insurrection, and menaced with foreign invasion,—the Marquis of Cornwallis was invested with the viceregal powers, and assumed the government in 1798. His administration was short, but successful: an invading army was made captive; some of the abuses which prevailed in the internal government of the kingdom were reformed, and tranquillity restored. On the union of Ireland with Great Britain, he resigned the government of the country, and returned to England. In 1801, he was appointed plenipotentiary to the congress assembled for the purpose of negotiating a general peace, which terminated in the definitive treaty of Amiens.

Having been thus from his early years actively, and almost uninterruptedly, engaged, in the service of his country, it might have been supposed, that his Lordship, who had now attained an advanced age, would have been permitted to pass the remainder of his life in the enjoyment of domestic repose. But the new and extensive acquisitions of the East India Company had brought their affairs into a state of embarrassment; and the talents and experience of the Marquis of Cornwallis, pointed him out as the individual most likely to restore order and tranquillity to our territorial possessions in Asia. In the year 1805, he accordingly repaired thither a second time, as Governor-General and Commander in Chief of the forces.

On his arrival at Calcutta, he found the finances of the country in a most deplorable state; while several of the most powerful of the native princes were still in arms, or preparing anew for hostilities. His first object, therefore, was to adopt a variety of arrangements, for the purpose of introducing order and economy into the civil department; and he then resolved to place himself at the head of the army, in order that, by an union of firmness and conciliation, he might accomplish what he justly conceived to be the most beneficial measure for our Indian territories, an honourable peace. But, at this critical moment, our eastern empire was unfortunately deprived of his services. Bodily fatigue, mental exertion, and the vicissitudes of climate, had undermined his constitution; and his health was now so much impaired, that he was obliged to perform his journey by slow and easy stages. Nature at length became completely exhausted; and he died on the 5th of October 1805, at Ghazepore, in the province of Benares, in the 66th year of his age. He was buried with great pomp; and every mark of respect was paid to his merit. The inhabitants of Calcutta voted a mausoleum, those of Bombay a statue to his memory. His Lordship was only once married; and left two children; the present Marquis and a daughter.

Marquis Cornwallis was endowed in no small degree with those qualities which lead to distinction, both in the cabinet and in the field, and rendered important services to his country, as a statesman and a general. In council he displayed moderation and coolness; in conduct, firmness, resolution, and vigour. In public life, he was distinguished by independence of character, and inflexible integrity; in private, he was respected and esteemed for his humanity and benevolence. (H.)

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AMONG the various schemes which have been devised for checking the alarming progress of pauperism in England, and which have been recommended as contributing to the comfort and happiness of the lower classes, in every stage of society, few seem to have obtained a greater degree of popularity, or to be more generally patronised, than the COTTAGE SYSTEM;—that system which proposes, under certain restrictions, to furnish the industrious poor with cottages and small pieces of land, to be used either for the purpose of keeping a cow, or of raising potatoes, or for some other species of husbandry.

It is not our intention, in this article, to detail the various peculiarities and modifications involved in the plans of the different authors by whom the efficacy of the cottage system has been maintained. We shall content ourselves with examining the accuracy of the fundamental principles on which the whole scheme is founded;—and, in so doing, shall endeavour to resolve the important question,—whether the more minute division of landed property, and the letting of small farms and patches of ground, to any considerable portion of the lower classes, would have any tendency to improve the condition and charac-

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ter of the bulk of the people, and to reduce the sum total of human misery?

As the effects of the cottage, or small farming system, on the condition of the poor, must, in a great measure, depend on the fact of its having a tendency to increase or diminish the exchangeable value of raw produce, it will be necessary, first of all, to inquire into its probable operation in this respect. If it has a tendency to reduce the price of corn, cattle, &c. and to render their acquisition less difficult, that will afford a strong ground of recommendation in its favour. But, on the other hand, if the cottage system has any tendency to raise the price of these commodities, and to make them exchange for a greater quantity of labour, its introduction would obviously be prejudicial to the interests of the entire community, and especially to those of the labouring classes.

obable ects of a nute Division of Landed Property the Price Raw Produce.

We have already endeavoured to explain how the price of raw produce has a natural tendency to rise, as society advances, and as a country becomes more populous. *(Principles of the Corn Laws.)* The best lands being first brought under cultivation, recourse is afterwards had to those of an inferior quality, requiring a greater quantity of labour to yield the same produce. The *real* price of that produce, which must always be regulated by the quantity of labour necessary to its production, is therefore increased; and it will henceforth exchange for a greater portion of those commodities, the production of which has not also become more difficult.

Had the inventive genius of man been limited in its powers, and had the ploughs, and harrows, and other machines and implements used in agriculture, at once attained their utmost degree of perfection, and ever after remained in the same state, the rise in the price of raw produce, consequent on the increase of population, would have been rendered much more apparent and obvious. When, in such a state of things, it became necessary to resort to poorer soils to raise an additional quantity of food, a corresponding increase of *manual labour* would have been required. On this hypothesis no improvement could take place in the powers of the labourer himself. Having already reached the perfection of his art, a greater degree of animal exertion could alone overcome fresh obstacles,—more labour would be necessary to the production of a greater quantity of food,—and it would be necessary in the precise proportion according to which the quantity of food had been increased. Thus, supposing the labour of *ten* men to have been previously required to produce *ten* quarters of wheat, in any given period, from land of a certain quality,—when *fifteen* quarters were produced in the same period, and from the same land, we should at once know that *fifteen* hands had been employed in its production. The effects of improved machinery are here entirely out of the question. And were it possible for the arts to continue in this stationary state, the price of raw produce would directly vary with every variation in the quality of the soils, successively brought under cultivation.

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But, in an improving society, the circumstances regulating the real and exchangeable values of raw produce are extremely different. Here, too, it no doubt has a constant tendency to rise: For, notwithstanding that every successive improvement in agriculture, and every new device by which labour can be saved, and the energies and powers of machinery augmented, has a direct tendency to *lower* prices,—still the rise of profits, and consequent stimulus given to the principle of population, by every fall in the price of raw produce, by increasing the demand, and *again* forcing the cultivation of poorer soils, must in the end raise its relative value. But this rise is rendered much less perceptible than it would be in a stationary state of society. After inferior soils have been brought under cultivation, more labourers will probably be required to raise the same quantities of food, but as the powers of the labourers themselves will be augmented, a smaller number will be required, in proportion to the whole work to be performed, than if no such improvements had taken place. It is in this way that the natural tendency to an increase in the price of raw produce is counteracted in the progress of society. The productive energies of the earth itself gradually diminish, and we are compelled to resort to soils of a constantly decreasing degree of fertility; but the productive energy of the labour employed in extracting produce from these soils, is as constantly improved. Two directly opposite and continually acting principles are thus set in motion. From the operation of causes to which we have alluded, the increasing sterility of the soil must, in the long-run, overmatch the increasing power of machinery, and the improvements of agriculture, and prices must experience a corresponding rise. Occasionally, however, improvements in the latter more than compensate for any deterioration in the quality of the former, and a fall of prices is the consequence. And should an equilibrium take place, and the opposite principles exactly counterpoise each other, prices would remain stationary.

Had the whole surface of the earth been originally of the same degree of fertility, and had an equal expenditure of capital and labour always continued to yield the same amount of raw produce, these effects of the improvement of machinery, and of the saving of labour in reducing its price, would have been quite palpable and obvious. Had this been the case, the exchangeable value of raw produce must have invariably *fallen* as society advanced. There would then have been no principle left to counteract the effects of agricultural improvements. The quantity of labour necessary for the production of every species of commodities would, because of the improvement of machinery, have been almost always diminishing; and, of course, their real price would have been as constantly on the decline.

It results, as a consequence of these principles, that any constitution of society, or any method of dividing landed property, which should have the effect of counteracting this improvement, or which

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should prevent agriculturists adopting the most efficacious methods for saving labour and expence in the raising of raw produce, would be materially injurious.

The rate of profit, and consequently the power to accumulate capital and population, is ultimately regulated by the price of raw produce. If its price is relatively low, that is, if it is *easily produced*, a comparatively small expenditure of labour will suffice to obtain a large quantity of produce. If, in a country thus circumstanced, property is protected, and full scope given to accumulation, the national wealth will rapidly increase. Where labour is more than ordinarily productive, although the labourer receives a large share of the produce of his own exertions, a large nett profit will also remain for his employer. In America labour is extremely well rewarded, but the profits of stock are, notwithstanding, much higher than in Europe. The choice of immense tracts of fertile and unoccupied land, relieves the farmers of the United States from the necessity of cultivating any but the richest soils. The wants of the country can be supplied without having recourse to lands of an inferior quality; and, although the wages of workmen are comparatively high, yet, as their labour is proportionably productive, capitalists realize a corresponding and ample profit.

The increased difficulty of raising raw produce, is the principal cause why all old settled and fully peopled countries advance slowly in the accumulation of capital and riches, and why the profits of their stock are comparatively low. Were it not, however, for the improvements which are constantly making in agriculture, this difficulty would be greatly increased. By enabling us partially to overcome the increasing sterility of the soil, improvements reduce the cost of production, or the real price of raw produce; and, by this means, the rate of profit, and consequently the power to accumulate wealth and population, is prevented from falling so low as it would do in a state of society, where such improvements could not be made.

But such, we apprehend, must necessarily be the situation of every country in which a minute division of landed property, or a generally extended cottage system, has been introduced. The produce of a small farm of five, ten, or even twenty acres, may perhaps enable its occupier to preserve his family from downright starvation, but it will never enable him to accumulate stock to any extent. "Where," asks Mr Young, "is the little farmer to be found who will cover his whole farm with marl, at the rate of 100 to 150 tons *per* acre? who will drain all his land at the expence of two or three pounds an acre? who will pay a heavy price for the manure of towns, and convey it 30 miles by land-carriage? who will float his meadows at the expence of L.5 *per* acre? who, to improve the breed of his sheep, will give 1000 guineas for the use of a single ram for a single season? who will send across the kingdom to distant provinces for new implements, and for men to use them? who employ and pay men for residing in provinces where practices are found which they want to introduce into their farms? At the very mention of such exertions, common in England, what mind can be so perversely framed as to imagine, for a single moment, that SUCH THINGS are to be effected by *little farmers? Deduct from agriculture* ALL *the practices that have made it flourishing in this island, and you have precisely the management of small farms.*" (*Travels in France*, 2d edition, Vol. I. p. 410.) Besides, if it were to be admitted that small farmers might accumulate capital, they could not *apply* it in the most efficient manner. "The division of labour, which, in every pursuit of industry, gives skill and dispatch, cannot take place on the greatest farms in the degree in which it is found in manufactures; *but, upon small farms it does not take place at all.* The same man by turns applies to every work of the farm; upon the larger occupation there are ploughmen, threshers, hedgers, shepherds, cow herds, oxherds, lime-burners, drainers, &c. This circumstance is of considerable importance, and decides, that *every work will be better performed on a large than on a small farm.* One of the greatest engines of good farming, a sheep-fold, is either to be found on a large farm only, or at an expence of labour which destroys the profit." (*Travels in France*, Vol. I. p. 409.)

Small Farms would increase the price of Raw Produce.

Neither could a small farmer make *use* of any but the simplest machines, and he must, in a great measure, be prevented from availing himself of the powers of the lower animals. An Irish cottager could not employ either a thrashing-machine or a horse. Manual labour only can enable him to extract produce from the earth. He cannot avail himself of natural agents, or render them subservient to the great work of production. That principle which, in countries where capital is accumulating in masses, and where the powers of machinery are every day rendered more efficient, tends to reduce the price of raw produce, and to render the necessaries of life attainable by a less expenditure of labour, is altogether incompatible with a minute division of landed property. Whatever additional supplies of food are required in a kingdom divided into small occupancies, can be produced only by a proportionable increase of animal exertion. And raw produce must, therefore, rise in price with every increase of population, or as soon as it becomes necessary to cultivate any portion of inferior soils. There is, in this case, nothing left to counteract increasing sterility. It is neither checked by improved machinery, nor by any expedients for saving labour. But, being allowed to exert its full effect, society very soon becomes clogged in its progress; and its future advancement is rendered extremely problematical.

This, we conceive, constitutes a fundamental objection to every attempt to introduce a plan for dividing landed property into minute portions. For, surely nothing can be more preposterously absurd than to think of relieving the hardships and distresses of the poor, by recommending the adoption of a scheme, which would infallibly tend to raise the price of the principal necessaries of life.

But a minute division of landed property is not merely disadvantageous, from its having a tendency to raise the price of raw produce; by preventing the *most advantageous distribution* of capital and labour, it must also exercise a powerful effect on

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manufactured commodities; and increasing the cost of their production must contribute to enhance their real price.

Effects of a minute Division of Landed Property on Manufacturing Industry.

In a country such as England, where an improved system of husbandry is generally introduced, where farms are extensive, and where the most improved machinery is employed in agricultural operations, a comparatively small proportion of the inhabitants is engaged in the cultivation of the soil. The rest are employed in manufacturing, in carrying the products of the different districts of the kingdom to where they are in the greatest request, and in exchanging them for the products of other countries. By this means, the national wealth and the comforts of all classes are augmented. Farmers are no longer obliged to spend their time in clumsy attempts to manufacture their own raw produce; and manufacturers cease to interest themselves about the raising of corn and the fattening of cattle. In an improved state of society, every class can bestow its undivided attention on some particular department of industry. Labour is not only economized, but it is perseveringly and judiciously applied. Agriculturists are stimulated to raise large crops, because they know they can readily exchange them for a greater proportion of other commodities conducing to their enjoyments; while manufacturers are equally inclined to increase the quantity and to improve the quality of their wares, that they may be enabled to command a greater quantity of raw produce. As valuable or desirable objects are multiplied, greater efforts will be made to procure them. A spirit of industry and a desire to rise in the world will be universally diffused, and that apathy and languor which is natural to a stationary state of society, will be scarcely known.

"It is," says Dr Smith, "the great multiplication of the productions of the different arts, in consequence of the division of labour, which occasions, in a well governed society, that universal opulence which extends itself to the lowest ranks of the people. Every workman has a great quantity of his own work to dispose of, beyond what he himself has occasion for; and every other workman being exactly in the same situation, he is enabled to exchange a great quantity of his own goods for a great quantity, or, what comes to the same thing, for the price of a great quantity of theirs. He supplies them abundantly with what they have occasion for, and they accommodate him as amply with what he has occasion for, and a general plenty diffuses itself through all the different ranks of society."

But if a country were generally divided into small farms, these effects could only take place in a very limited extent. Where a great proportion of the inhabitants are directly supported by the produce of the soil, it is obvious that there must be less of that produce to support other classes. Agriculturists will not then have it in their power to purchase any considerable quantity of manufactured goods; nor will manufacturers have it in their power to purchase a large share of the produce of the soil. Neither capital nor labour could, in such circumstances, be employed in the most advantageous manner; and that division of labour, to whose effects Dr Smith has justly ascribed the greater part of the improvement of society, would only be partially introduced. A considerable portion of the coarser sorts of manufactured commodities would then be prepared, though at a much greater expence, at home; for the small surplus of agricultural produce that would remain, after satisfying the wants of the cultivators, would be barely sufficient to produce such necessaries as could not be produced by the rude efforts of agricultural labourers. Being obliged to engage by turns in every different employment, workmen would be prevented from acquiring a proper degree of dexterity in any.* But as it is by the *quantity* of labour expended on a commodity, that its exchangeable value is regulated, it is obvious that, with a minute division of landed property, not only the price of raw produce, but of every species of manufactured commodities, would be increased. Labour would, therefore, become proportionably less powerful in procuring them, and hence the situation of the great body of the people, who have only labour to give in exchange for commodities, would be rendered comparatively wretched. No person would have any, or but very little surplus produce to dispose of; and instead of general opulence, we should meet with nothing but universal poverty. "The tendency of such a system," says an able and intelligent writer who had carefully observed its effects, "*is to approximate man to the state of the savage, where the insulated being is obliged to supply himself by his own labour with every thing that his situation may require.*"

A minute Division of Landed Property would render the Occupiers of Land entirely dependent on the Landlords.

It deserves to be mentioned, that a minute division of landed property, by preventing the general extension and improvement of manufactu-

* "In Ireland, the minute division of land, and the manner in which the inhabitants are scattered over the country, *render it necessary for labour of various kinds to be combined in the same individual; and thus each family becomes the manufacturers of their own clothing, and of every thing else which they use.* Most of the raw materials being supplied either by their flocks, or the produce of their land, they are better able to continue this system, and to dispense with the use of articles imported or made by regular workmen. In arts carried on in this manner, *improvement is impossible;* and while the same system exists, no taste can be excited for a superior mode of life, nor will much encouragement be given to the establishment of manufactories. Except in the cotton branches, and in the curing of provisions, this pernicious system is everywhere observed; it pervades all ranks, from the nobleman, who makes his own candles, cultivates his own patch of flax, and has it spun by his servants, to the cotter, whose wife and daughters spin and manufacture the frieze and woollen stuffs which serve them as clothing." (Wakefield's *Account of Ireland*, Vol. I. p. 760.)

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ring industry, would render the occupiers of land almost entirely dependent on its proprietors. Those farmers who had incurred the displeasure of their landlords, would not be able to betake themselves to another employment, and would be obliged to submit to every species of indignity. The state of society, during the middle-ages, approached, in some respects, very near to this; and, it should be remembered, that the division of labour, and the general extension of commerce and manufactures, has been still more beneficial, from its having effected the abolition of villenage, and removed the grinding oppression of feudal tyranny, than from its having multiplied the comforts and conveniencies of life. Nor is it less certain, that every discovery of a new channel into which productive industry may be advantageously turned, must afford an additional guarantee for the permanent enjoyment of our personal freedom and independence. By enlarging the field of employment, and adding to the means of acquiring an independent livelihood, while it increases the comforts of every individual, it also renders them less liable to be affected by derangements in any particular branch of business; or by the errors, partialities, whims, and caprices, of those in authority.

It is impossible that the prizes in the lottery of human life can be too much multiplied. The greater the variety of ways by which men can rise to eminence, the greater will be the efforts made to rise. In a country where full scope is given to the accumulation of property, the mind of every individual, even of those in the humblest walks of life, is cheered with the idea, that, by industry and economy, he may better his situation, emerge from obscurity, and attain to opulence. But in an essentially agricultural society, and where the greater part of the population are directly supported on the produce of the soil, there can be little variety of condition. In a country thus circumstanced capital could not be accumulated, large cities could not exist, and the liberal arts and professions, which chiefly depend on them for protection and support, and to which they owe their birth, would neither be patronised nor indulged in. It is not to be imagined, that cultivators, engrossed, as small farmers must constantly be, with the thoughts of providing for their present wants, should pay any attention to schemes of general or prospective improvement. Such men have no sufficient motive to stimulate them to exertion; and a perpetual sameness, like that of China, or, at most, a nearly imperceptible progress, is all that could be there expected, and is all that would take place. It is only in countries like America or England, that the energies of man, as well as those of the soil, can be developed in their full extent. The diversity of the objects of pursuit, will there give ample room for gratifying the diversity of dispositions; while the applause consequent on any invention that either extends the power of man over the physical world, or enlarges his intellectual faculties, will perpetuate the discoveries made and the spirit which makes them.

Effects of the Cottage System.

A great part of the misconceptions and erroneous opinions to be met with respecting the cottage system, appear to have originated in hasty and premature attempts at generalization, founded on a few limited observations of its local effects. But first appearances are, in this case, of all others the most fallacious. The effects observed to result from the partial granting of cottages, furnish no clue to trace the ultimate consequences of their general introduction. These effects are, on the contrary, of an entirely different character, and are eminently calculated to mislead. Were cottages, with small pieces of ground attached to each, let at a moderate rent to a few of the most industrious labourers in the best cultivated districts of Great Britain, there can be no doubt, but that the circumstances of those individuals would, in the first instance, be meliorated. They would acquire these possessions with previously formed habits of industry and economy. When their own little farm did not require their exertions, they would be able to find employment in the more extensive farms in their vicinity; and, in return for their labour, they would be able to procure the ploughs, harrows, and carts of their neighbours to assist them in their different operations. The labour of such men would thus be employed with nearly the same effect that it would have been had they continued as farm-servants on estates managed in the first style. It is even probable, that their exertions would at first be rather increased; inasmuch as a part of the labour necessary for the cultivation of the small farm would be executed at extra hours, and after the ordinary day's labour had been performed.

Would probably be advantageous at first:

But the truth of this statement is nowise inconsistent with the truth of the principles we have been endeavouring to establish. The *ultimate* and necessary consequences of a minute division of landed property deserve to be as much attended to, as those which are only immediate and transitory.

But would ultimately be extremely prejudicial.

In the *first* place, then, it is extremely probable, that the small farmers would, ere long, become disgusted with that life of unremitting exertion which they had formerly led. It is natural to suppose, that, having attained to a state of comparative independence, and not being under the *necessity* of constantly employing themselves, occasional intervals of relaxation would take place. However small we may conceive the possession of the cottager to be, he would still have some species of produce to dispose of. A habit would, in this way, be formed of going to market, and time would be lost in the adjusting of trifling bargains. "Nothing," as Mr Young has justly remarked, "can be more absurd, than a strong hearty man walking some miles, and losing a day's work, in order to sell a dozen of eggs or a chicken, the value of which would not be equal to the labour of conveying it, if he were properly employed." Such habits, too, are almost sure to lead to dissipation. The small farmer must have his porter and his gin as well as the extensive farmer. It is the want of time and opportunity, still more than the want of money, that prevents a hired labourer from having it in his power to ape the conduct of his employers. The circumstances, too, which distinguish a farm servant from a farmer, are much better defined, and more easily appreciated, than those which distinguish a small farmer from an

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extensive one. The latter are both placed, if we may use the expression, in the same cast; and hence the extravagances of the small farmer, though equally hurtful to himself and his family with those of a labourer, are much less an object of animadversion in the neighbourhood. They clash less with popular prejudices, and with the received opinions of mankind, and there is, therefore, a greater probability of their being more indulged in.

If these consequences of the introduction of small farms, should not become obvious in the lifetime of the first occupiers, they would certainly discover themselves in that of their successors. Not having undergone the same rigid training with their fathers, the habits and prejudices of the two races would be essentially different. And the character of the industrious labourer, which had predominated in the first, would, in the second, give place to that of the half employed, petty, farmer.

But, in the *second* place, it is obvious, that the beneficial effects observed to result from the first introduction of small farms, depend almost entirely on the occupiers of these farms or patches of ground, having it in their power to employ themselves at other work when their labour is not necessary at home. Now, with a generally extended cottage system, this could not be the case. Where *all* the farms are small, none would require the labour of extra hands, nor would they afford their own possessors constant employment, except, perhaps, during seedtime and harvest. Nor is it to be imagined, that the leisure of a poor cottager, thus situated, should have anything in common with the leisure of an extensive farmer or capitalist. The cottager is inactive, not because he has already realized an ample fund to support him in a state of comfortable independence, but he is inactive because no exertions can better his fortune, and because there is no demand for his labour. No man, it should be recollected, loves either exertion or industry for their own sakes. All have some end in view, some object to effect, and the accomplishment of which is to compensate for the toils and privations to which they may at present submit. But a small farmer is almost entirely cut off from all hope of rising in society. No person possessed of capital would ever think of embarking in such a hopeless concern; and after supporting a family, no small farmer, originally without capital, would ever be able to accumulate any. As it is impossible for him to escape from poverty, the cottager, naturally, becomes indolent, careless, and relaxed in his habits. His opinions of what is necessary to his comfortable subsistence become degraded; and he ultimately sinks into a state of apathy, and of sluggish and stupid indifference.

Effects of the Cottage System in Ireland.

That such is really the state of society in every country in which landed property is divided into minute portions, is abundantly certain. But we have no occasion to go from home to seek for an exemplification of its effects. We have only to turn to Ireland. The cottage system has there been submitted to the test of experiment, and it is proper that the result should be generally known.

In our inquiry into the principles of the corn laws, we have endeavoured to show how the granting of high bounties on the exportation of corn from Ireland, in 1780 and 1784, contributed to the extension of tillage, and to the breaking up of the pasture grounds in that kingdom. But the want of capital, and the consequent impossibility of procuring tenants capable of taking large farms, obliged the proprietors to divide their lands into small portions. Large tracts of old grass land were ploughed up, and let in farms of from ten to twenty acres: and in this way the stimulus, intended to act as an incitement to agricultural improvement, has had a much more powerful effect in causing the subdivision of farms, and in increasing the merely agricultural population of the country.

Mr Newenham's authority is decisive as to this fact. "Large farms," he informs us, "of from 500 to 1500 and 2000 acres, once so common in Ireland, hold actually no sort of proportion to farms of from 10 to 30 or 40 acres. In the county of Down, Mr Dubordieu says, that farms run from 20 to 40, 50, and in *some instances* as far as 100 acres. Such is the case in most other parts of Ireland. For several years past the landlords of that county have been much in the habit of letting their lands in *small divisions*. Besides this, the *cotter system*, or the giving a certain quantity of land as an equivalent for wages, prevails throughout most parts of Ireland. In fact, *upwards of four-fifths of the Irish people are subsisted chiefly on the produce of the land which they hold*." (*Inquiry into the Population of Ireland*, p. 270.)

Every part of Mr Wakefield's valuable work on Ireland, abounds with interesting information respecting the *effects* produced by this minute division of landed property. Our limits, however, will only permit our extracting the following passages.

When noticing the state of landed property in the county of Kerry, Mr Wakefield observes: "Few persons here occupy such a quantity of land as to oblige them to employ a labourer; it is not, therefore, customary for people to go from their own homes to work, and, indeed, none but those who have taken very dear farms, and experience the necessity of procuring a little ready money, ever think of it. This system, considered in a public point of view, strikes me as being exceedingly injurious. A country occupied by inhabitants whose ambition is so limited, that they have no desire to push their industry beyond that indolent exertion which procures them the bare necessaries of life, must remain without improvement. Such people cannot be said to *live*, but to *exist*; to supply their animal wants is the chief object of their labour, and if they can raise money enough, by the sale of butter and pigs, to pay their rent, all their care and anxiety is ended. The existence, however, of these wretched beings, depends entirely on the season; for if their potatoe crop fails, they are in danger of being starved. This mode of life, instead of elevating the moral faculties in the slightest degree, tends only to depress and degrade them. It becomes the parent of idleness, the worst evil that can afflict human nature, and that habit, if it spreads or becomes general, must lead to national poverty, and even want, with its concomitants, vice and misery." (*Account of Ireland*, Vol. I. p. 262.)

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"In Fermanagh," says he, "whether it arises from habit, or a natural propensity to indolence, the people do not rise until a late hour in the morning, and the cows are not milked till *noon*. There being but a poor market for the produce of the earth, *little encouragement is afforded to industry*, they therefore seldom think of turning their time to the best advantage." (*Account of Ireland*, Vol. II. p. 745.)

In his chapter on rural economy, Mr Wakefield makes the following *general* observations: "The Irish cotter's only anxiety is, that the butter and the pig sold, and the labour given to his landlord, may be equal in value to the payment which he has to make. When satisfied on this head, his mind is at rest; he has no further wants, and neither he nor his family consider labour as of any importance to their happiness. His potatoes are left in the ground till the commencement of frost makes him apprehend that his food may be locked up in the earth; and though very great inconvenience has been occasioned by this negligence, the repeated experiment of the bad result arising from it, has not yet been able to induce the peasantry of Ireland to adopt a better method. It is very common to hear persons of higher rank observe, when a very early frost takes place, that 'it is a fortunate event, as it will oblige the *poor* to dig up their potatoes;' *(for the* POOR *and the* CULTIVATOR OF THE SOIL *are here synonymous expressions,)* and of course they will be saved before a severer one sets in." (*Account of Ireland*, Vol. I. p. 517 and 583.)

It is not necessary to quote authorities to prove the miserable state of the hovels, in which the cottagers reside. Notwithstanding his prejudices in favour of the state of society in Ireland, Mr Newenham admits, "that a *bedstead* is a luxury which a great majority of the Irish labouring poor are strangers to. And as for clocks, warming-pans, frying-pans, tea-kettles, cups and saucers, &c. &c. which we find in every cottage here, I believe it is unnecessary to say, that they *never* constitute a part of the poor Irishman's furniture." (*Inquiry respecting the Population of Ireland*, p. 280.)

We shall close these statements with an important extract from Mr Curwen's late work on Ireland. This experienced agriculturist travelled through the greater part of it in 1813; and after having carefully inquired into the condition of the small farmers and cottagers, gives the result of his investigation, in the following terms: "The size of farms, from 15 to 30 acres, would give an average of about 22 or 23 acres to each. Portions of these are again subset to cotters, whose rents are paid by labour done for the tenants; from whom they sometimes receive milk and some other necessaries. These running accounts are an endless source of dissatisfaction, of dispute, and of contention at the quarter-sessions. *In some of the more populous parts of Ireland, there is supposed to be an inhabitant for every acre, while the cultivation of the soil, as now practised, does not afford employment for a third of that population.* In the north, where the linen trade has been established, the lower classes are weavers, which gives them a great superiority over the southern districts. The labour on the highways and great roads, for which such large assessments are made on the counties, afford, for a portion of the year, a great source of employment.

"The minute subdivision of lands among these occupants is attended with many serious evils. The rents of these small sublet parcels become so high to the actual cultivators, as to preclude all profitable returns from their labour. It affords too great a facility to marriage. The population becomes increased beyond the capital of the country employed in husbandry, and the supernumerary individuals are compelled to subsist on the produce of others' labour, to which they have no power of contributing. The aggregate number of horses is greater than would be required, if the estates were distributed into moderately sized farms; while the want of farming buildings, besides other disadvantages, prevents the accumulation of manure.

"The labourers, with few exceptions, are all married. The farmers have no hired servants, of either sex, residing in their dwellings; this is another serious evil arising out of small farms. Ireland, which in extent is nearly equal to one half of Great Britain, does not probably employ one tenth of the agricultural servants.

"The buildings on every farm being erected at the expence of the tenant, are necessarily on the most limited scale, seldom more than a cabin, and this insufficient for the children of the family beyond their earliest days. As the children grow up, they are compelled to seek another establishment for themselves, and to hazard every consequence that may ensue. Alternative they have none. The interests of all parties suffer, and it would be for the advantage of the whole community to promote a *radical reform* of the present disreputable system."

Effects of the Division of a Country into small Freehold Properties.

Such are the ruinous effects produced by the small farming system! And such too, with some few exceptions, would be the effects of having a country parcelled out into small FREEHOLD PROPERTIES. A few words will be sufficient to show the similarity of the cases.

First of all, it is obvious, that, in a country divided into small properties, the division of labour would be quite as inapplicable, as in a country occupied by small farmers. The proprietor of ten, twenty, or fifty acres, can as little afford to keep ploughmen, hedgers, thrashers, &c. as the person who holds them on lease. But whatever may be the capital of the occupier of a small farm, its *size* will not admit of its being farmed in such a manner as to yield the largest quantity of produce, with the least possible expenditure of labour.

Until very lately, it might have been contended, that, in a country occupied entirely by proprietors, raw produce would be sold at a cheaper rate than in one occupied by farmers, who, in addition to the expence of labour, would be also burdened with payment of rent. This, however, is not really the case. The price of raw produce, as well as of manufactured commodities, is regulated solely by the quantity of labour necessary to its production. Rent, it has been demonstrated, does not enter into price. Corn is not high because a rent is paid, but a rent

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is paid because corn is high; and Mr Malthus has justly observed, that no reduction would take place in the price of corn, although landlords should forego the whole of their rent. Such a measure would only enable some farmers to live like gentlemen, but would not diminish the quantity of labour necessary to raise raw produce, on the least productive land in cultivation.

Although, therefore, it cannot be doubted, that the condition of the greater part of the *occupiers of land*, in a country divided into small proprietorships, would, on the whole, be preferable to their condition in a country divided into small farms, it is certain that the condition of every other class in society would be the same in both cases. The price of the produce raised by the small farmer and proprietor would be equally high. Neither of them would be able to bring their corn and cattle to market on the same reasonable terms as an extensive farmer. The profits of stock would, therefore, be rendered less than they would be in a country where agriculturists are enabled to adopt every expedient, by which labour can be saved, or rendered more efficient; and hence the power of the whole society to accumulate wealth and riches, would be proportionably diminished.

In the *second* place, small properties as well as small farms, have a strong tendency to increase the agricultural population of a country, in a ratio far exceeding the demand. A property of forty or fifty acres of good land, might support a single family in tolerably easy circumstances; but what is to become of their children? No country, it will be remembered, which is divided into small occupancies, can ever furnish a sufficient surplus produce, after satisfying the wants of the cultivators, to maintain a numerous body of merchants, manufacturers, handicraftsmen, &c. There can therefore be no demand for the surplus population, which an agricultural society is always producing; and the division of the paternal property is the only way in which families can be provided for. This, however, is only making bad worse. Forty or fifty acres of property are not incapable of pretty good cultivation; but twenty or twenty-five, and still more ten or twelve acres, *must* be ill cultivated. But in an essentially agricultural country, such, for example, as France, where the right of *primogeniture* is in a great measure unknown, and where landed properties are usually divided in equal portions among all the children, or at least among all the sons of a family, properties will very soon be reduced even below *ten* acres. They must, in fact, be perpetually lessening, until, to use the words of Mr Young, when pointing out the pernicious effects of this system in France, "you arrive at the limit, beyond which the earth, cultivate it as you please, will feed no more mouths; yet those simple manners, which instigate to marriage, still continue:—what then is the consequence, but the most dreadful imaginable! By persevering in this system, you soon would exceed the populousness of China, where the putrid carcases of dogs, cats, rats, and every species of filth and vermin, are sought with avidity, to sustain the life of wretches who were born only to be starved. Small properties much divided prove the greatest source of misery that can possibly be conceived; and this has operated to such an extent and degree in France, that a law undoubtedly ought to be passed, to render all division, below a certain number of arpents, illegal."—(*Travels in France*, Vol. I. pp. 413, 414.)

The condition of the agricultural classes in France has been very much ameliorated since Mr Young visited that kingdom. The abolition of the feudal privileges of the nobility and clergy, and of the gabelle, the corvées, and other grievously oppressive and partial imposts and burdens, would of themselves have sufficed to render the condition of the farmers and small proprietors more respectable and comfortable. A great part, too, of the property of the church, and of the emigrants, came into their hands at extremely low prices. By this means small properties were augmented, and fresh energy and vigour was given to agricultural pursuits. Still, however, the too minute division of landed property, and the consequent excess of *country* population, forms the prime evil in the social condition of the people of France. "The population of that country," says Mr Birkbeck, "seems to be arranged thus: A town depends for subsistence on the lands immediately around it. The cultivators individually have not much to spare; because, as their husbandry is a sort of *gardening*, it requires a large country population, and has, in proportion, less superfluity of produce. Thus is formed a numerous but poor population. The cultivator receives payment of his surplus produce in sous, and he expends only sous. The tradesman is on a par with the farmer; as they receive so they expend; and thus 50,000 persons may inhabit a district, with a town of 10,000 inhabitants in the centre of it, bartering the superfluity of the country for the arts and manufactures of the town. Poor from generation to generation, and growing continually poorer as they increase in numbers, in the country, by the division and subdivision of property; in the town, by the division and subdivision of trades and professions. *Such a people, instead of proceeding from the necessaries to the comforts of life, and then to the luxuries, as is the order of things in England, are rather retrograde than progressive. There is no advancement in French society; no improvement, nor hope of it.*"—(*Tour in France*, 4th edit. p. 34.)

Whether Property in Land is the most efficient instigator to Labour?

It has been said, that property in land is of all others the most active instigator to severe and incessant labour. This, however, is a very doubtful proposition. It is true, that the exertions of the proprietor of a little farm are not paralyzed by any apprehensions of his being turned out of the possession before he has reaped the reward of his labours. But, on the other hand, his certainty of a resource, his dependence on the produce of a small piece of ground from which he cannot be ejected, and which will preserve him from absolute want, joined to the impossibility of his rising in the world, have a strong tendency to foster habits of relaxation and indolence. A farmer can never calculate with certainty on getting a renewal of his lease. Unless he has accumulated some capital, he is always exposed to the risk of being thrown destitute upon the world; but it is not so with the small proprietor. He relies for sup-

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port not on capital, but on land. He is exempted from all chance of being turned out of his possession; and cannot, therefore, have the same powerful motive to accumulate stock as the other. The small proprietors and farmers of France, Mr Birkbeck informs us, " having absolutely no means of improving their situation, submit to necessity, and pass their lives contentedly." The same is the case in Great Britain. " Throughout England there is no comparison between the case of a day-labourer and of a little farmer: we have no people that work so hard and fare so ill as the latter." (Young's *Travels in France*, Vol. I. p. 415.) And it is an indisputable fact, that those counties of Scotland, Kinross for example, where property is very much divided, are uniformly behind in their agriculture, and are farmed in a much inferior style to those where estates are more extensive.

It is foreign to the object of this article, to discuss the comparative moral and political effects produced by the division of landed property into large and small portions. We shall only observe, that a starving population, restricted to a dependence on the mere necessaries of life, is not very likely to be imbued with a just sense, either of the dignity or of the civil rights of man. An agricultural population, spread over a wide extent of country, has no point of reunion. Men only feel their own consequence,—they can only act in a collective capacity, and with vigour and effect, after they have been condensed into masses and collected into cities. It is comparatively easy to animate the inhabitants of a large town with the same spirit,—there is a sympathy in their gladness and in their sufferings,—the redress of an injury done to a single individual, becomes in some measure the business of the whole. But, with agriculturists, the case is different,—they can be trampled down piecemeal,—they cannot act collectively, and must, therefore, submit themselves with less resistance to the yoke of the oppressor. Of all the arguments in favour of a minute division of landed property, that which supposes it would powerfully contribute to keep alive a feeling of manly independence, seems the most futile and preposterous.

Probable effects of the Cottage System as a Scheme for relieving the Distresses of the Poor.

As a plan for relieving the distresses of the poor, the cottage system is perhaps the very worst that can be devised. It should always be borne in mind, that, except in the case of maimed and impotent persons, there can be no poor in any country that ought to be relieved, unless the population is positively redundant. As long as the supply of labour does not exceed the demand, the whole industrious part of the community may be employed. In such a state of society none but the idle and the profligate can be without work, and the means of subsistence; and it will not, we presume, be contended that cottages ought to be built for their reception. In all cases, however, where the poverty and distress of the people proceed from a redundancy of population,—and that is the case whenever industrious persons are unable to procure wages sufficient to purchase the ordinary necessaries and comforts of life,—surely it would be most absurd to attempt to ameliorate their condition, by introducing a system, which, whatever might be its immediate effects, would lead to a still greater redundancy of population. Such would, most unquestionably, be the effect of the introduction of the cottage system. A person who gets a lease of a cottage and a small piece of ground, finds himself in a situation to marry. No longer dependent for mere subsistence on the good will of his employers, but feeling, if not an increase of wealth, at least an increase of security against want, the cottager is naturally stimulated to contract that engagement, into which men are otherwise sufficiently prone to enter. A cottage could not, indeed, be of any use to a single man. Either a wife or a female servant would be required to superintend its domestic economy; and as a cottager could not afford the payment of wages, it is easy to perceive which of the two he would prefer.

No person would think of attempting to relieve the pressure and distress occasioned by any sudden derangement or revulsion in the affairs of the commercial world, by proposing the adoption of a cottage system. The plan of granting cottages has only been recommended in cases where a permanent difficulty has been experienced in the procuring of employment. But in every such case the cure is worse than the disease. Where the population is redundant, and an industrious man can never be long without employment from any other cause, it should be our object not to accelerate but to retard the rate of its increase,—not to increase but to diminish the number of cottages.

Cottage System would reduce the Wages of Labour.

Neither the circumstance of the general extension of the cottage system increasing the price of raw produce, by its preventing the accumulation of capital and the improvement of machinery, nor its tendency to disseminate a spirit of idleness and of dissipation, are half so injurious to the labouring classes, as the effect it would have in giving a factitious stimulus to population. Although it were possible, and certainly it is not, immediately to provide for all the paupers in England, by granting them cottages and small pieces of land at a moderate rent, in the course of a few years that country would be in a still worse situation than at present. What would become of the families of these paupers? If the cottage system be once fairly introduced, where shall it stop? If it was proper to relieve the distresses of the sires in this way, why not also apply it to the case of the sons? The call for relief would, in the latter case, be more pressing than in the former, inasmuch as the population would have become more superabundant. It would then be impossible to retrace our steps. A fresh allotment of cottages would have to take place, and a fresh stimulus would again be applied to population. In this way the cottage system would at length overspread the whole country. " The principle of gravitation," says Mr Ricardo, when speaking of the poor laws, and it is still more applicable to the scheme for granting cottages, " is not more certain than the tendency of such a system to change wealth and power into misery and weakness; to call away the exertion of labour from every object except that of providing mere subsistence; to confound all intellectual distinction; to busy the mind continually in supplying the body's wants; un-

til at last all classes should be infected with the plague of universal poverty."

Notwithstanding the extraordinary advances which Great Britain made in the interval between 1788 and 1812 in the accumulation of wealth and capital, and notwithstanding we were then able to engross almost the whole commerce of the world; yet, even then, and when the plan of giving cottages to the poor was but very partially adopted, the supply of labourers increased much faster than the demand for their exertions, and their real wages consequently declined. Now, when such is the indisputable fact, would it not be the extreme of folly, especially in the present situation of the country, to hold out any extraordinary inducements to the increase of the population? If the existing inducements to marry were sufficiently powerful to cause too great a supply of labourers to be brought into the market, even when there was an unusual demand for them, it would be most unwise to endeavour to strengthen those inducements at any time, and especially after the unusual demand had subsided.

The fact of the cottage system having a tendency to give a factitious stimulus to population, and hence to cause a reduction of the real wages of labour, is of itself enough to satisfy every unprejudiced inquirer of the pernicious effects it must have on the condition of the lower classes. But its bad effects would not stop there. After landed property had been divided into minute portions, and after population had begun to press against the limits of subsistence, cottagers, in order to preserve their families from want, would have recourse to those crops which yield the greatest quantity of food from the smallest extent of ground. An extensive farmer cultivates those crops only, which exchange for the greatest quantity of money, or, what is the same thing, of other commodities necessary to his wants and comforts. With the small farmer, however, the case is different. He too would wish to raise that species of produce which would have the greatest exchangeable value; but the necessities of those depending on him for support must first be provided for. A cottager, with five, ten, or fifteen, acres of land, could not possibly support himself and a family on wheaten bread and butcher meat. He would be forced to betake himself to some less expensive fare,—to relinquish first one enjoyment and then another,—and from one step to another, according as the increase of population increased the competition for cottages, POTATOES would at length constitute his only food.

Although the real price of labour fluctuates with every fluctuation of the demand and supply, it is, like every other commodity, possessed of exchangeable value, ultimately regulated by the expence of production. Where labourers consider neat cottages, comfortable clothes, bread and beef, tea, &c., as necessary to their comfortable or decent subsistence, and where, unless they have a prospect of being able to command these enjoyments they are less inclined to marry,—the wages of labour are necessarily high. But, under the cottage system, wages would not merely experience a temporary depression from an excessive supply, but they would be *permanently reduced*. Workmen would then be raised at a comparatively small expence. And wages, being no longer regulated by the cost of wheat, beef, &c., but of potatoes, a species of food raised at the least possible expence, they would sink to the very lowest point.

From the fact of manufactured commodities always falling, and raw produce always rising (See *Principles of Corn Laws*) with the progress of society, such a disproportion in their relative value is at length created, that, in those countries where labourers are chiefly supported on corn, beef, &c., and where wages must of course be mainly regulated by their price, they are able, by sacrificing a small portion of their food, to provide liberally for all their other wants. But where the potatoe forms the ordinary food of the lower classes, the operation of this principle is scarcely perceptible. Potatoes, it is true, as well as corn, rise in real value as society advances, and as it becomes necessary to have recourse to poorer soils for their cultivation; but, under any circumstances, the quantity of labour required to produce as many potatoes as will feed a workman, bears but a small proportion to the labour necessary to produce corn or butcher meat for the same purpose. In a comparative point of view, therefore, very little additional command over manufactured commodities could be gained by a labourer diminishing his consumption of potatoes; and hence the present condition of the inhabitants of a country chiefly supported by that root, is not only much worse than it would be were they supported on some more expensive food, but their future prospects are rendered still more gloomy and discouraging.

It would not be an easy task to enumerate all the evils to which a country is exposed, when the real wages of labour are reduced extremely low, or when they are regulated by the price of the cheapest species of food; but they are unquestionably of the most appalling description. When wealth is accumulated in a country, the more opulent and middle classes, and even the lower orders, consume considerably more than the mere necessaries of life. In a season of scarcity, this consumption being diminished, the effect is the same as if an additional supply of provisions were imported from abroad. But when the mass of the population is already dependent on mere necessaries for their support, they cannot diminish their consumption. In a nation thus circumstanced, individual consumption must remain nearly the same, and a deficient crop is sure to entail disease, famine, and death, on a considerable portion of the community. This is no very alluring prospect held out by the cottage system, but it would be fully realized. In a country abounding in capital and manufactures, when a bad harvest happens, these are exported, and corn is brought home from every quarter of the world. But what superfluous produce could a nation of cottagers or, rather we should say, of paupers, have to dispose off? Millions die in China and Hindostan whenever there is any serious deficit in the rice crop. The extremity of want is felt in Ireland when the potatoe is not ordinarily productive; and the sole reason why famines are not as frequent there as in China, is because the cottage system is not yet universally introduced, and because some capitalists are still to be found in that country. (s. s.)

COTTON MANUFACTURE.

Cotton Manufacture.

SINCE the period when the cotton manufacture was treated of in the *Encyclopædia*, its importance to the country has much increased. An immense capital has been invested in it; and, in consequence of the progress which has been made in the perfecting of its mechanical processes, an extraordinary increase of its products has been obtained. These circumstances impart a fresh interest to the subject; and we, therefore, propose to give the article anew; arranging it in the form of a historical view of the rise and progress and present state of the Cotton Manufacture in the different countries where it is carried on, and embodying in the narrative an account of the various mechanical inventions to which it has given rise.

Cotton Manufacture of India.

The cotton manufacture had its origin in the East, where the cotton plant is indigenous, and where the climate renders a light and absorbent fabric a suitable clothing for the people. It has in consequence been long established everywhere over that quarter of the world, though it is only in India that it is carried on extensively, with a view to foreign exchange.

Arrian mentions cotton cloth among the commodities which the Romans brought from India; but from the use which that people made of the bath, woollen was the general wear, and, therefore, the quantity of cotton goods imported by them was not considerable. Dr Robertson remarks, that the difference between the cargoes imported from India, in ancient and in modern times, appears to have arisen, not from any diversity in the nature of the commodities prepared for sale in that country, but from variety in the tastes or in the wants of the nations with which they trade.

The implements made use of in the cotton manufacture of India are of so rude and simple a construction, that they are evidently the invention of a very early period. It is probable that they existed, as we now find them, before the people of that country were divided into casts; for the continuing of a particular employment in the same family, which seems to belong to that artificial construction of society, while it had the effect to transmit unimpaired the knowledge already acquired in the art, puts a stop to farther progress.

There is, indeed, no law in the Hindoo code which prescribes a division of employment within cast, but it is the invariable practice, that the profession or occupation which the father has followed, shall be pursued by the son.

From the perpetuated course of training to which this gives rise, is obtained that dexterity which each individual, in his particular employment, possesses beyond what is to be found elsewhere; but undeviating adherence to established practice precludes all developement of talent, and reduces man to the condition of a machine. Any improvement in the art, while the human mind remains thus locked up, appears impossible. It is, however, the opinion of Mr Rickards, who so ably advocated the interests of the natives of India, in the discussions in Parliament on the renewal of the Company's charter, that, latterly, this form of society, with all its peculiar habits and restraints, has been held together chiefly by the oppression of the fiscal exactions, the want of a free trade, and the consequent universal poverty of the people, which prevents any expansion of their faculties; and, in support of this opinion, he refers to what the Hindoo population of Calcutta and Bombay have achieved in the pursuits of commerce, within a very recent period.

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The whole implements used by the Indians in the different processes of the cotton manufacture, from the cleaning of the wool to the converting of it into the finest muslin, may be purchased for the value of a few shillings. With the exception of their loom, there exists among them no manufacturing instrument that can bear the name of a machine, nor is there any trace of the Hindoos having ever displayed any mechanical ingenuity. They spin their yarn upon the distaff; and yet with all the advantages which we derive from machinery, we have never been able to equal, either in fineness or quality, the yarn which they produce by means of this primitive instrument. The loom upon which their cloth is woven, is composed of a few sticks or reeds, which the weaver, carrying them about with him, puts up in the fields, under the shade of a tree, digging a hole large enough to contain his legs and the lower part of the "geer," the balances of which he fastens to some convenient branch over his head. Two loops underneath the geer, in which he inserts his great toes, serve as treadles, and the shuttle, formed like a large netting-needle, but of a length somewhat exceeding the breadth of the cloth, he employs also as "batton," using it alternately to draw through the weft and strike it up. The loom has no beam; the warp is laid out upon the ground, the whole length of the piece of cloth. On this account the weavers live entirely in villages, as they could not, if shut up in towns, work in this manner. Forbes says, "the weavers' houses are mostly near the shade of tamarind and mango trees, under which, at sunrise, they fix their looms and weave a variety of very fine cloths."—(Forbes's *Oriental Memoirs.*) The reed is the only part of the weaving appartus, which approaches in perfectness of construction to the instruments we use. Upon this rude machine, worked in the way we have mentioned, the Indians produce those muslins, which have long been such objects of curiosity, from the exquisite beauty and fineness of their texture.

From the superiority of these goods, and from their being said to retain their appearance longer than European muslins, it has been erroneously

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supposed that the cotton of which they are made is of better quality than any known to the European manufacturer. This is a mistake; they have no cotton in India of a quality equal to the best *Sea Island;* and the excellence which their muslins possess, is to be ascribed wholly to the skilful tact of the workmen in the processes of spinning and weaving. The well managed use of the finger and thumb of the Indian spinner, patiently and carefully applied in the formation of the thread, and the moisture at the same time communicated to it, have the effect of incorporating the fibres of the cotton more perfectly than can be accomplished by our machines. While in the weaving process, the Indian, to be able to manage his ill-constructed loom, even in the production of ordinary fabrics, is obliged to acquire such dexterity and sleight of hand, that it is not surprising, if, out of the multitude trained in this manner, a few should be found capable of producing those muslins said to be of such fineness, that, when spread upon the grass, they appear like the gossamer's web.

But how dearly is this excellence of art purchased by the sacrifice of the better faculties of man! How different is the effect produced by this branch of industry, upon the people and circumstances of India, from that produced by it upon the people and circumstances of England. This manufacture, though probably carried on in India to its present extent, for some thousand years, has given birth to no inventions,—to nothing which could contribute to the means of procuring enjoyment,—to nothing calculated to improve man's condition or to enlarge the sphere of his happiness. In England it has existed for only fifty years, and in that short time has given rise to some of the happiest efforts of ingenuity. It has been of incalculable use in promoting mechanical skill, and in improving the power of execution in our artizans; and the demand for additional mechanical power, created by the extension of its processes, has led to the perfecting of the steam-engine, the most successful attempt which man has ever made to bend the properties of matter to his will. How many roads, canals, and bridges, has the circulation of its products brought into existence, and how many new markets of every thing the soil can supply, has it been the cause of establishing throughout the country!

In India, this manufacture not only has no effect, in improving the condition of the people, but does not appear even to afford to those engaged in it, the means of accumulating the capital necessary to its own existence; for the funds which keep this branch of industry in motion, in place of being supplied from the stock of the master manufacturer, are advanced by the purchaser of the goods.

Thus, in the case of the East India Company's investments, the funds which are to enable the manufacturer to produce the goods, are advanced by the Company's commercial Resident, a person appointed to take charge of this part of the business. To assist this officer in his duties, he has under him a number of European servants of the Company, and an establishment of native clerks, and of people termed peons, whose business is to watch and control the weavers.

The Resident, when he has to provide an investment, enters into contracts for the goods, either with the native merchants acting as brokers, or with the master manufacturers or headsmen, and these parties make subsidiary engagements with the weavers. The Resident then advances money for carrying on the work, to the chief contractors, who distribute it to the different classes of workmen, and are responsible for the delivery of the manufactured goods into the Company's warehouse, in the state stipulated in the contract. The commercial Resident never interferes with the arrangements or operations of the contractors, except when complaints are made of delay or fraud, arising from the interference of other brokers or contractors acting for other parties than the Company; and then a host of peons is sent forth by him to intimidate, and if necessary to coerce the weavers.

The Resident, when not engaged in providing goods for the Company's investment, is authorized to employ the weavers on his own account. This greatly increases his influence over these people, who having him constantly among them, as head of the little colony, and being unable at any time to move a step without his advances, feel themselves in a state of such entire dependence upon him, that although the brokers who make contracts for the Portuguese and others are generally willing to give higher prices than those which he arbitrarily fixes, the weavers, however they may be disposed to elude his orders, or to outwit him in his operations, never venture openly to dispute his will. Various laws and regulations have been enacted, to protect these poor people in their transactions with the Company's agents; but where the sovereign is the chief trader, and a party in the cause, the impartial administration of justice is not to be looked for. The very fine muslins are manufactured at Dacca, in the district around which the best cotton is produced. But those fabrics, of such exquisite fineness as to have been poetically compared to "webs of woven wind," are considered more as articles of curiosity than of trade, and their use is confined almost exclusively to the families of the potentates and princes of the country, who keep agents in this place to superintend the workmen employed in their manufacture.

Common muslins are made in every village throughout the Peninsula. Orme says, that "when not near the high road, or a principal town, it is difficult to find a village in which every man, woman, and child is not employed in making a piece of cloth." (*Historical Fragments of the Mogul Empire*, by Robert Orme.)

The long cloths and fine pullicats are made chiefly within the presidency of Madras, the coarse piece-goods and pullicats at Surat; the finest calicoes at Masulipatam, and table-cloths of a superior quality at Patna. But every district varies from the rest in the nature of some of its productions, as may be seen from the different denominations of cotton goods to be found in every investment coming from India.

An apprehension has been expressed, that the inhabitants of India, in possession of the raw material,

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may obtain a knowledge of our machinery, and by combining with its peculiar advantages their cheaper labour and superior manual dexterity, be enabled to undersell us to such a degree, as to ruin and put an end to our manufacture. But in the state of the people of India, there are circumstances which render this impossible, without a change being first produced upon their moral condition, their institutions, and habits. The training which makes the Indian, with such imperfect tools, able to perform his work so well, disqualifies him from doing it in any other way, or with other implements than those to which he has been familiarized from his infancy. Besides, the uncertainty of success, and the length of time which it would take to try the experiment, are sufficient securities against the attempt being made.

Meantime, however, a revolution has been taking place in the trade between India and this country; and indeed between India and all the countries on this side of the Cape of Good Hope. The introduction of machinery so extensively into our processes, has enabled us to reduce the price of our manufactures so much, that we now not only maintain a successful competition with the India goods, in markets formerly supplied exclusively with them, but we export cotton goods to India itself.

When we first got possession of that country, our investments home were principally (in point of value, almost entirely) composed of manufactured produce; they are now in a very great proportion made up of the produce of the soil, as indigo, cotton wool, raw silk, saltpetre, &c. &c. Should this continue to be the case, and from the circumstances which have been stated, there is every ground for believing that it will,—how severe must its effects be upon the crowded population of a country, which in all ages has been a great manufacturing and exporting community!

Cotton Manufacture of China.

The cotton manufacture of China is of immense amount, and carried on almost entirely for home consumption. But its origin is not of the same remote date as that of India. Indeed, the lateness of its rise, and the slowness of its progress in a situation so favourable, appear extraordinary. In the accounts of the revenues and of the arts of China, during the period of the celebrated dynasty which commenced about 1100 years before the Christian era, and lasted for some centuries, no mention is made of the cotton *plant*, or of any thing connected with cotton;* nor indeed is there any notice of cotton in these records, until about 200 years before the Christian era; from which period to the sixth century, the cotton cloth, that was either paid in tribute, or offered in presents, to the emperors, is always mentioned as a thing rare and precious. The annals record, as a singular circumstance, the emperor Ou-ti, who mounted the throne in 502, having had a robe of cotton. In the seventh century, we find the cotton plant mentioned, but as being confined to gardens, and the poems and romances of that period are occupied in celebrating the beauty of its flowers. From these circumstances we may venture to say, that there could have been no manufacture of the article in the country at that time; which appears the more surprising, as cotton cloths were highly prized at Court, and are always noticed among the offerings made to the emperors by the ambassadors of foreign princes. It was in the eleventh century that the cotton plant was first removed from the gardens to the fields, and became an object of common culture; and it is not until this period that we can date the commencement of the manufacture. So slow and backward sometimes are nations, far advanced in other respects, in prosecuting objects, considered afterwards by them as indispensable to their comforts. And how extraordinary is this, in the case of the Chinese, a people possessed of so much ingenuity, and known to be so much awake to every thing connected with self interest.

The cotton *tree* was introduced into China at the time of the conquest of that country by the Mogul Tartars, in the year 1280; after which period every encouragement was given by government to the culture and manufacture of cotton. But there were considerable difficulties to be encountered in the prejudices of the people, and in the opposition of those engaged in the manufacture of woollen and linen; and it was not until the year 1368, that these obstacles were altogether surmounted. After that date the progress of the cotton manufacture was rapid, and now, nine-tenths of the population of that immense empire are clothed in its fabrics. All the cotton cloth used by the Chinese for garments is coloured, white being the dress employed for mourning, and never worn but on that occasion.

Almost the only cotton goods exported from China are nankeens, and a few chintzes. Barrow mentions, that the cotton from which the former article is made, when cultivated in the southern provinces, is said, from the greater heat, to lose its peculiar yellow tint, in the course of two or three years. But this Mr Barrow thinks cannot be the case, having himself, he says, raised the nankeen cotton at the Cape of Good Hope, and found the third year's crop of as full and rich a tint as the first. He states the production of all the fabrics of the Chinese manufacture at the time he visited the country in 1792 to be stationary, attributing this to the want of proper encouragement from the government, and to the rigid adherence of the people to ancient usage. But to keep a manufacture in a progressive state, there must be a progressive demand for its products; and the Chinese manufacturers having no means of disposing of any surplus quantity, must shape the supply to the wants of their own consumption. It is said by travellers who have obtained access to that country, that the people show a great desire for articles of British manufacture. How valuable then would the establishment of a free intercourse be to both countries, and how conducive, probably, to the increase of the productions of both?

The Chinese, over and above the cotton wool

* *Du Cotonnier et de sa Culture*, par Lasteyrie. 8vo. Paris, 1808.

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they raise at home for their manufacture, import largely from India. This intercourse commenced about 40 years ago. A famine, which happened in China about that period, induced the government to direct, by an imperial edict, that a greater proportion of the land should be thrown into the cultivation of grain. Since then, the importation from India has been considerable, although constituting but a small part of what is consumed in their manufacture. Small, however, as they consider it, its amount has been nearly equal to a half of the quantity required for the whole cotton manufacture of Great Britain.

Introduction of the Cotton Manufacture into Europe.

The manufacture of cotton goods in Europe, it is said, was first attempted by the Commercial States of Italy, before the discovery of the passage to India by the Cape of Good Hope. These enterprising communities had till then been the medium through which the cotton fabrics of India had passed to the different markets of the west; and being situated in the neighbourhood of countries where the cotton wool was grown, and familiar with manufacturing processes, they had been led, it is supposed, to attempt the imitation of articles so much valued, and so profitable of sale. Another speculation, however, places the introduction of the cotton manufacture into Europe at a later date, and states the people of the Low Countries to have been the first manufacturers of these articles, in imitation of the cotton fabrics which the Dutch, about the beginning of the seventeenth century, began to import from India. But this last account cannot be correct; for Guicciardini, in 1560, in a very full list which he gives of the different articles annually imported into, and exported from, Antwerp,* then the greatest commercial mart in Europe, specifies fustians and dimities of many fine sorts, among the manufactured articles imported from Milan, and mentions cottons generally among those brought from Venice. But in the articles exported from Antwerp, although we find linens sent to almost every country, cotton cloth is not once mentioned. Italy, therefore, at that time, had a cotton manufacture, which, it is probable, soon after made its way to the Netherlands; for we know that it was brought from thence to Britain, by Protestant refugees, about the close of the sixteenth, or early in the seventeenth century.

Introduction of the Cotton Manufacture into England.

That this manufacture was carried on in this country at a pretty early period of the seventeenth century, we know from good authority. Lewis Roberts, in his "*Treasure of Traffic*," published in the year 1641, says, "The town of Manchester buys linen yarn from the Irish in great quantity, and weaving it, returns the same again in linen into Ireland to sell. Neither does her industry rest here; for they buy cotton wool in London, that comes from Cyprus and Smyrna, and work the same into fustians, vermillions, and dimities, which they return to London, where they are sold, and from thence not seldom are sent into such foreign parts where the first material may be more easily had for that manufacture."

These goods were woven chiefly about Bolton, and were purchased there at the weekly market, by the Manchester dealers, who afterwards finished them, and sold them to their customers over the country.

Early state of the Manufacture in England.

At this period, and for a long time after, the weaver provided his own warp, which was of linen yarn, and the cotton wool for his weft, buying them wherever he could best supply himself. But, as the trouble of looking about for these materials when he wanted them, was found to be an unprofitable application of his time, the Manchester purchasers established agents in the different villages to supply those articles, and receive in return the goods when manufactured. In this way of conducting the business, each weaver's cottage formed a separate and independent little factory. The yarn for his warp was bought by him in a prepared state, the wool for his weft was carded and spun by the female part of the family, and the cloth was woven by himself and his sons.

This is the situation in which we find manufactures every where before the introduction of machinery, and particularly before the manufacture has been carried to such an extent as will allow of a division of labour, and a separation of the different processes into distinct employments. At this period of the business, the workman usually has his residence in the country, where he can be accommodated with a little garden ground, and perhaps with grass for a cow; and there in the bosom of his family, aided by the industry of its different members, prosecutes his employment. How much more of the comforts of life, and of the means of natural enjoyment, belong to this stage of the manufacture than to a more advanced one, in which combined systems of machinery, and a more perfect division of labour, collect the workmen into factories and towns!

It would be impossible to enumerate all the descriptions of cotton goods which, in succession, were brought forward from the commencement of the manufacture.† The pattern cards of the principal houses in the trade, circulated from time to time through these kingdoms, and over the continent of Europe and America, exhibited specimens of nearly two thousand different kinds, comprehending, in the assortment, every variety of taste and fancy.

For the introduction and after improvement of many of these articles, the country is indebted to the late Mr John Wilson of Ainsworth. This gentleman was originally a manufacturer of fustians at Manchester, and had early engaged in the manufac-

* See Macpherson's *Annals of Commerce*.

† The fustians which were made in this early period of the manufacture, were those denominated herring-bone, pillows for pockets and outside wear, strong cotton-ribs and barragon, broad raced linen thickset and tufts, with whitened diaper, striped dimities, and jeans. At some distance of time, there were added to these, cotton thicksets, goods figured in the loom; and, at a still later date, cotton velvets, velveteens, and strong and fancy cords. (Aitkin's *History of Manchester*.)

ture of cotton velvets, which, by persevering efforts, he succeeded in bringing to the utmost degree of perfection. His improvement of the mode of dressing, of finishing, and particularly of dyeing these goods, acquired to them so great a character, both in the home and foreign market, that they always sold in preference to those of every other manufacturer. He cleared off the loose and uneven fibres from them with razors, and then burned or singed them with spirits of wine. Afterwards he made use of hot irons, resembling the weavers' drying iron, which instrument had been first employed for this purpose in the manufacture carried on in the Manchester house of correction, by Mr Whitlow, governor of that establishment. At a later period, Mr Wilson effected the same object, by drawing the goods rapidly, and equally, over a cylinder of cast-iron heated to redness, by which they were in a still superior manner cleared of the down or pile which had been raised upon them, in the various operations of weaving, washing, bleaching, or dyeing. These successive inventions of Mr Wilson, for performing this process, give us some idea of the manner in which improvements are introduced into our manufactures, when, fortunately, the efforts of self-interest come to be directed by intelligence and talent.

Mr Wilson having a turn for chemical inquiries, investigated the different known processes of dyeing; and, by the improvements he introduced, in the application of them to his own manufacture, materially advanced that art. Having succeeded to his satisfaction in dyeing the other rich colours, he procured from the Greeks of Smyrna the secret of dyeing Turkey red. He afterwards gave an account of this process, in two *Essays*, which he read to the *Philosophical and Literary Society of Manchester*, and which, upon retiring from business, he printed and distributed among his friends. The many valuable improvements introduced by him into the different processes connected with the cotton manufacture, had the effect, not only to establish it more firmly, but rapidly to enlarge its extent.

A considerable share of the calico-printing business, about the year 1760, was transferred from London to Lancashire, in consequence of the cheaper accommodation there for carrying on the work, and the lower wages the Lancashire workmen were content to accept for their labour. This cheapness produced an increasing demand for calicoes. These goods were at that time made of linen warp and cotton weft, it having been found impracticable before Sir Richard Arkwright's discovery, to spin cotton yarn of sufficient strength for the former.

At this period, the dealers from Manchester, in place of buying fustians and calicoes from the weaver, as had been the practice before, began to furnish him with materials for the cloth, and to pay him a fixed price *per* piece for the work when executed. Along with a portion of linen warp, they gave him out a certain quantity of cotton wool, which he was obliged to get spun into the weft he was to use. But so fast was the manufacture by this time outstripping the process of spinning, that it frequently happened that the sum the weaver was allowed by his employer for the spinning, was less than what he found himself obliged to pay for it. He durst not, however, complain, much less abate the spinner's price, lest his looms should be unemployed. In this state of things, the farther progress of the manufacture must have been stopped, if a more productive mode of spinning had not been discovered.

It has been said, that the yarn produced at this time in England by the *one thread wheel*, the only spinning machine known, did not exceed in quantity what 50,000 spindles of our present machinery can yield. To have reared and trained hands sufficient to have doubled this quantity, had it been possible, must have been the work of a length of time, and the amount of the manufacture would still have been insignificant. A change in the system, therefore, had become indispensable; and we find, that different ingenious people had already begun to employ themselves in contriving a better mode of spinning.

When we contrast the splendid inventions connected with the cotton manufacture, which, from this period, burst forth in rapid succession, with the passive acquiescence in the use of imperfect machinery during the long period which preceded, we are apt to ascribe these improvements to the circumstance alone of a number of men of genius at that moment having shone out upon the world, and to forget that the ultimate cause exists in the times which have called that genius into action.

Progress of Improvement in the Carding Process.

Previously to the year 1760 improvements had been attempted in the carding process. James Hargreaves, a weaver at Stanhill, near Church, in Lancashire, an illiterate man possessed of no great mechanical knowledge, had adapted the stock-cards used in the woollen manufacture to the carding of cotton, and had greatly improved them. By their means a person was able to do double the work, and with more ease, than by hand-carding, the method practised till then. In the stock-cards one of the cards is fixed, while the other being suspended by a cord over a pulley, is worked by the carder; and in this way two or three cards can be applied to the same stock. This contrivance was soon succeeded by the cylinder cards, or carding engine. It is not ascertained who was the inventor of this valuable machine, but it is known that the father of the present Sir Robert Peele was among the first who used it; and that, as early as the year 1762, he, with the assistance of Hargreaves, erected a carding engine with cylinders, at Blackburn. This machine did not differ materially from that now in use, except that it had no contrivance for detaching the cotton from the cards, an operation which was performed by women with hand-cards. About the same period the fly-shuttle, one of the most important improvements that has been introduced into the process of weaving, was invented by a person of the name of Kay at Bury.

Fly-shuttle invented.

These successful advances show how much the minds of the manufacturing class had been awakened to discovery, and must have encouraged the efforts that were then making to effect like improvements in spinning.

Cotton Manufacture.

James Hargreaves invents the Spinning Jenny.

There had been several unsuccessful attempts to improve the mode of spinning before the year 1767, when James Hargreaves, whom we have already mentioned, invented the "spinning *jenny*." The idea of this machine is said to have been suggested to him, by seeing a common spinning wheel which had been accidentally overturned, continue its motion while it lay on the ground. If this was the case, it shows a mind of no common description, which, from such a casual occurrence, could elicit an invention of so much importance.

Description.

After several unsuccessful attempts to carry into execution the conception he had formed, he succeeded in producing a rudely constructed *jenny* of eight spindles, turned by bands from a horizontal wheel. In it, the eight rovings were passed between two pieces of wood laid horizontally the breadth of the machine, and these being grasped in the spinner's hand and drawn out by him, formed the rovings into threads. The structure of this *jenny* was afterwards greatly improved, and it was at last brought to work as many as eighty spindles. This machine, although of limited powers, when compared with the beautiful inventions which succeeded it, must be considered as the first and leading step in that progress of discovery, which carried improvement into every branch of the manufacture; changing, as it proceeded, the nature and character of the means of production, by substituting mechanical operations for human labour, and causing the manufactured article to become more and more a product of capital. The progress of invention after this was rapid; for when it was seen that, with the aid of the few mechanical combinations we have mentioned, the spinner had been enabled to increase his power of production nearly eighty fold, those engaged in other branches of manufacture had their attention awakened to the possibility of introducing changes equally beneficial, by an application of similar contrivances.

Hargreaves's invention occasioned great alarm among those who earned their subsistence by the old mode of spinning, and even produced popular commotion. A mob broke into his house and destroyed his machine; and, some time after, when a better knowledge of the advantage of his invention had begun to bring his "spinning *jenny*" into general use, the people rose a second time, and, scouring the country, broke to pieces every carding and spinning machine they could find. Hargreaves himself had now removed to Nottingham, where he was engaged in erecting a small spinning work about the same period when Mr Arkwright came to settle there, being also driven from Lancashire by the fear of similar violence.

The *jenny* having in a short time put an end to the spinning of cotton by the common wheel, the whole wefts used in the manufacture continued to be spun upon that machine, until the invention of the "mule *jenny*," by which, in its turn, it was superseded. Hargreaves died in great poverty a few years after his removal to Nottingham.

Sir Richard Arkwright's Spinning Frame.

It would appear that while Hargreaves was producing the common *jenny*, Mr Arkwright, afterwards Sir Richard Arkwright, was employed in contriving that wonderful piece of mechanism, the spinning frame; which, when put in motion, performs of itself the whole process of spinning, leaving to man only the office of supplying the material, and of joining or piecing the thread when it happens to break.

Cotton Manufacture.

The extraordinary person to whom we owe this invention was born in the year 1732, at Preston in Lancashire, of parents in poor circumstances, and he was the youngest of 13 children. He was brought up to the humble occupation of a barber, and even to the time that he made his discovery, he continued to derive his subsistence from the exercise of this employment. But living in a manufacturing district, his attention, it is probable, had been drawn to the operations carrying on around him, and hearing from every one complaints of the deficient supply of cotton yarn, he set about contriving a plan for changing the mode of spinning.

Even after he had matured in his mind the conception of what he proposed to execute, he had great difficulty in giving his ideas a practical form, from his total want of mechanical skill and experience. And, at the last, his discovery was likely to have been lost to the world, from his not being able to find any person willing to embark the capital that was necessary to give the undertaking a fair trial. None but a person of his ardour and perseverance could have overcome such obstacles.

It has already been mentioned, that he had removed to Nottingham; here he prevailed upon the Messrs Wrights, bankers, to advance him the sums of money necessary to enable him to go on with his experiments, it being understood, that if his plan should succeed, they were to share in its profits. These gentlemen, however, finding the amount of their advances swell to a larger sum than they had expected, while there seemed to them little prospect of the discovery being brought into a practical state, informed Mr Arkwright, that the transaction being out of the ordinary course of their business, they would be glad if he could get some one to take their place, and pay them up their money; and they mentioned Mr Need of Nottingham, as a person likely to do this, from his being already engaged in other patent discoveries, and acquainted with such undertakings. Mr Arkwright in consequence applied to Mr Need, who told him he had no objection to join in the scheme, if he could be satisfied that the discovery was such as he represented it; and who desired him to carry the model of his machine to Mr Strutt of Derby, his partner in the stocking patent, by whose report he would be guided. Mr Strutt, a man of great mechanical skill, seeing at a glance the merit of the invention, and how little was required to render it complete, told Mr Need that he might with great safety close with Mr Arkwright; the only thing wanting to his model, being an adaptation of some of the wheels to each other, which, from a want of skill, the inventor, with all his powers of contrivance, had not been able to accomplish.

In the year 1769, Mr Arkwright obtained his patent for spinning with rollers; and Mr Need and Mr

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Arkwright obtains his first Patent for Spinning with Rollers.

Strutt became his partners in the concerns to be carried on under it. He erected his first mill at Nottingham, which he worked by a horse power. But this mode of giving motion to the machinery being expensive, he, in the year 1771, built another mill at Cromford, in Derbyshire, to which motion was given by water.

In the year 1772, his patent was contested, on the ground that he was not the original inventor of the process for which it was obtained; but a verdict was given in his favour, and his right to the exclusive use of the discovery remained afterwards undisturbed.

Obtains a second Patent for Machinery for Preparing Cotton.

Mr Arkwright, soon after his removal to Cromford, followed up his first great discovery with other inventions and combinations of machinery for preparing the cotton for spinning, by which perfection was gradually given to the process through all its successive operations. For these additional improvements he took out another patent in the year 1775. But, in the year 1781, his right to this patent was disputed, on the plea that he was not the inventor of some of the mechanical contrivances comprehended under it; and after different trials of the question before the Courts of King's Bench and Common Pleas, judgment was finally given against him in November 1785, and the patent cancelled.

Description of Sir R. Arkwright's Inventions.

We shall now proceed to give a description of Mr Arkwright's different inventions, not, however, in the order in which he brought them forward, but in that in which they are employed in the process of spinning, of which art, in its present state, this will enable us at the same time to exhibit a view.

Cards.

The cotton-wool, after it has been carefully picked, either by the hand or by a machine, is carried to the carding engine. This machine consists of two or more large cylinders, covered with cards, with teeth like those of hand-cards, which revolve in opposite directions, and nearly in contact with each other. These cylinders are either surmounted by other smaller ones, covered in like manner with cards, by whose revolutions in opposite directions to those of the larger cylinders, and with different velocities, the cotton is carded, and put on the last or finishing cylinder; or, as is now more generally practised, the first cylinder, that is, the one nearest the feeder, is surrounded by a fixed concave framing, lined with cards, which, coming nearly in contact with the cylinder cards, produce the same effect in the process as the top cylinders, and in a more simple manner. See Plate LXVII. Fig. 1, 2, 3, and 4.

We have noticed, in speaking of the carding engine which Mr Peele erected in 1762, that, at that time, the cotton was taken off the finishing cylinder by means of hand-cards. But by the time Mr Arkwright began his spinning, this operation was performed by the application of a roller, with tin plates upon it, like the floats of a water-wheel, which, revolving with a quick motion, scraped off the cotton from the card. This was a rude contrivance, and in its operation injured both the cotton and the cards. Mr Arkwright substituted for it a plate of metal, toothed at the edge like a comb, which, in place of being made to revolve like the other, was moved rapidly in a perpendicular direction by a crank, and with slight but reiterated strokes on the teeth of the cards, detached the cotton from them in a uniform fleece. In place also of sheet cards, with which the finishing cylinder had hitherto been covered, he employed narrow fillet cards, wound round it in a spiral form, by which contrivance a continuity of the fleece was produced, which, as it left the card, was gradually contracted in its size, by being passed through a kind of funnel, and then flattened or compressed between two rollers, after which it was received into a tin can in the state of a uniform continued carding.

The taking off the cotton from the cards in this manner is one of the most beautiful and curious operations in the process of cotton spinning: and although the crank, which forms a part of the apparatus, had perhaps been used in some way or other prior to the date of Mr Arkwright's second patent, as was urged in the action for having it set aside, the comb for taking off the fleece, and the spiral card which produces its continuity, were inventions indisputably his own.

Drawing Frame.

The next step in the process after the carding is, what is called drawing the cotton. The machine employed for this purpose, called the drawing frame, is constructed upon the same principle as the spinning frame, from which machine the idea of it was taken. To imitate the operation performed by the finger and thumb in hand-spinning, two pairs of rollers are employed; the first pair, slowly revolving in contact with each other, are placed at a little distance from the second pair, which revolve with greater velocity. The lower roller of each pair is furrowed, or fluted longitudinally, and the upper one is neatly covered with leather, to give the two a proper hold of the cotton. If we suppose a carding to be passed between the first pair of rollers, it will be drawn forward as they move, but without any change in its form or texture, farther than a slight compression received from the incumbent roller. But if from the first pair it be passed through the second moving with twice or thrice the velocity of the first, it will be drawn twice or thrice smaller than it was when it entered the first rollers. In the succeeding operation, two, three, or more of these drawings are passed together through the rollers in the same manner, coalescing as they pass, and forming a single new drawing. This doubling and drawing is several times repeated, having the effect to arrange all the fibres of the cotton longitudinally, in a uniform and parallel direction, and to do away all inequalities of thickness. In these operations the cotton receives no twist. See Plate LXVII. Fig. 5. and 6.

Roving Frame.

Roving the cotton, which is the next part of the process of preparation, is an operation similar to that employed for drawing it, only that, to give the rove, in its now reduced thickness, such a degree of tenacity as will make it hold together, a slight twist is given to it, converting it into a soft and loose thread. This is effected, by passing it as it leaves the rollers, into a round conical can, which, while receiving it, revolves with considerable velocity. (See Plate LXVII. Fig. 7, 8, and 9.) After this the rove is wound by the hand upon a bobbin by the

Cotton Manufacture.

younger children of the mill, and carried to the spinning frame.*

Spinning frame.

The spinning frame has the double set of rollers, which have been described in the account given of the drawing and roving frames, and which, operating in the same manner as in those machines, extend the rove, and reduce it to a thread of the required fineness. The twist is given to this thread, by the application of the spindle and fly of the common flax wheel adopted into the machine for this purpose. (See Plate LXVIII. Fig. 10.)

When we consider the merits of Mr Arkwright's invention of the spinning frame, the circumstance which strikes us most, is the little resemblance there is between it and the spinning wheel in use at the time the discovery was made. It is not that machine improved by him, but a new instrument for performing the process in a better manner. And when this is kept in view, how extraordinary it appears, that a contrivance so original, and so finely conceived, should be the production of a person in his circumstances. His after inventions for preparing the cotton, which are sometimes spoken of as the finest thing to be observed in the process of cotton spinning, are certainly not so wonderful as this first effort of his genius; for, besides the advance in mechanical knowledge which he must have made by the time he produced them, the spiral cards, and the comb for taking off the finished carding, although contrivances which only an original and fertile mind could have conceived, are still but improved arrangements or dispositions of parts of a machine which previously existed; and the other parts of his apparatus for preparing the cotton, however excellently and beautifully fitted to produce their end, are but applications of his own spinning machine, altered and adapted to the accomplishment of this object.

But the originality and comprehension of his mind were perhaps marked by nothing more strongly, than the judgment with which, although new to business, he conducted the great concerns his discovery gave rise to, and the systematic order and arrangement which he introduced into every department of his extensive works. His plans of management, which must have been entirely his own, as no establishment of a similar nature then existed, were universally adopted by others; and, after long experience, they have not yet, in any material point, been altered or improved.

Water Twist.

The yarn produced by this mode of spinning is called Water Twist, from the circumstance of the machinery from which it is obtained, having, for a long time after its invention, been generally put in motion by water.

The Throstle.

The only improvement, or even alteration yet made upon Mr Arkwright's first contrivance, the spinning frame, is to be found in the machine called the Throstle introduced some years ago; the spinning apparatus employed in which, however, is in every respect the same as that in Mr Arkwright's frame, though the movement of the parts is different. In place of four or six spindles being coupled together, forming what is called a head, with a separate movement by a pully and drum, as is the case in the frame, the whole rollers and spindles on both sides of the throstle are connected together, and turned by bands from a tin cylinder, lying horizontally under the machine. In the throstle, too, a greater number of spindles are contained in the same space. But its merit lies in the simplification of the moving apparatus just mentioned, which not only renders the movement lighter, but affords the means of increasing, with greater facility, the speed of the machine; and consequently, when the nature of the spinning admits it, of obtaining a larger production. Besides this, the throstle can, with more ease, and at less expence than the frame, be altered to spin the different "grists" of yarn; only a few movements having to be changed in it to produce this end, while in the spinning frame there are a great many. (See Plate LXVIII. Fig. 11.)

In the year 1786 Mr Arkwright had the honour of knighthood conferred upon him, on presenting an address from the county of Derby, of which he was then High Sheriff.

Stocking Yarn.

From Mr Arkwright having commenced his operations at Nottingham, the seat of the stocking manufacture, and from his connection with Mr Need, who was largely engaged in it, the whole produce of his spinning at first was devoted to that trade. The cotton yarn for this manufacture requires to be particularly smooth and equal; and to secure to it these qualities, it is spun by a process differing a little from that employed for ordinary twist; being from two roves in place of one, it is called double spun twist. The introduction of this article produced a great change upon the stocking manufacture: hand spun cotton was entirely laid aside, and stockings made of twist were of so superior a quality, that in a short time they wholly supplanted thread stockings, which hitherto had been preferred. The manufacture of cotton stockings in Nottinghamshire, Derbyshire, and Leicestershire, is now of great extent.

Stocking Manufactures.

It was soon discovered, that the yarn produced by the spinning frame had sufficient strength to fit

* Since this article was written, a change in the process of roving has been introduced into many mills, and is expected to become general. In place of the rove being received in a roving can, as described above, it is now received upon a bobbin, by means of a spindle and fly. The spindle moving with a uniform speed, communicates an equal twine to the rove; while the bobbin, turned by a band which moves upon a cone, has its speed varied so as to take up the rove equally in all the different stages of the filling of the bobbin. This process saves the expence and trouble of winding the rove by hand, and, it is thought, occasions less waste than the other. But from the greater number and complexity of the movements of this machine, its parts require to be very perfect, and to be kept in the highest order.

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it for warp; but that the firmness and hardness of texture which gave it this quality, rendered it less suitable for weft than that spun by Hargreaves's *jenny*. In consequence, however, of the manufacturers being now enabled to procure cotton thread of this description, the calicoes and other articles in imitation of India goods, which had hitherto been manufactured with linen warp, came to be made wholly of cotton, and the progressive increase of these manufactures, particularly of calicoes after this time, was unexampled.

Cotton Warp Spun.

Calicoes made entirely of Cotton.

Calicoes wove with cotton warp were first attempted at Derby, in the year 1773, by Mr Need and Mr Strutt, Mr Arkwright's partners. But after these gentlemen had made a considerable quantity of those goods, they discovered, that when printed, they were subject to double the duty charged upon calicoes wove with linen warp, and that their sale was even prohibited in the home market. After a long and expensive application to the legislature, they succeeded in procuring the repeal of those impolitic laws. Nearly about the same period, calicoes entirely of cotton, were begun to be made at Blackburn, which place soon became the principal seat of their manufacture, and for a long time the great market to which the printers, from all parts of the kingdom, resorted for their supplies. This branch went on increasing for many years in a most extraordinary degree. About the year 1805, it was calculated, that the number of pieces of calico sold annually in the Blackburn market, was not less than a million; and by that time the manufacture of this article was not confined to the country round Blackburn, but had spread into the north-west district of Yorkshire, principally about Colne and Bradford, from which part of the country 20,000 pieces weekly, it is said, were sent to Manchester.

Mr Crompton invents the Mule *Jenny*.

In the year 1775, Mr Samuel Crompton, of Bolton, completed his invention of the "mule *jenny*," in the contriving of which he had been engaged for several years. But this machine did not come into general use until after the expiration of Mr Arkwright's patent, because, till then, the spinner was confined to the rove prepared for common *jenny* spinning, which was so unsuitable to the mule *jenny*, that it was apprehended this invention would prove abortive.

After the spinner was allowed to make use of Mr Arkwright's fine preparation, by his patent being cancelled, the powers of this machine became known, and its introduction forms another important era in the history of the cotton manufacture. For, being fitted to supply those *grists* and qualities of yarn which the other machines could not produce, the manufacturer was enabled to enter upon fabrics which otherwise it would have been vain to attempt. Warps of the finest quality are spun upon the mule, while, on the spinning frame, yarn finer than what is called No. 50 cannot be spun to advantage. The reason is, that the fine thread has not strength to stand the pull of the rollers when winding itself on the bobbin of the spinning frame, a stress which is saved to it in the mule, where the draught takes place only in a slight degree faster than the rove is given out by the rollers. All wefts, from the lowest to the highest numbers, are now spun upon this machine, the use of Hargreaves's *jenny* having been entirely superseded by it.* It was some time indeed after the mule came into use, before it was ascertained that the finest yarn required for the manufacture might be produced from it. But, by the year 1792, Mr Jonathan Pollard of Manchester had come to spin yarn upon the mule of the fineness of 278 hanks to the pound, from cotton wool grown by Mr Robley, in the island of Tobago; which yarn was sold at 20 guineas *per* pound to the muslin manufacturers of Glasgow.

Description of the "Mule *Jenny*."

The mule, in its structure and operation, is a compound of the spinning frame, and of Hargreaves's *jenny*, from which circumstance it has probably received its name. It contains a system of rollers like that belonging to the twist frame; but, in place of having every four or six of them in separate heads, as is the case in that machine, the whole are coupled together, and the rove being drawn through them, is, in its conversion into thread, received on spindles revolving like those of the *jenny*. The carriage on which these spindles are placed is moveable, and is made to recede from the rollers a degree faster than the thread is given out. After a certain quantity of the roving has been thus delivered by the rollers, they are stopped, but the carriage continues to recede somewhat farther, and the spindles continuing also to revolve, the thread is drawn out to the fineness required, and then receives its proper portion of twist. This last operation resembles that performed by the common *jenny*, and produces a similar effect. (See Plate LXVIII. Fig. 12.)

Mr Crompton took no patent for this discovery, but many years after he had given this important invention to his country, he received from Parliament a grant of L.5000.

Mr Kelly's Patent for giving Motion to the Mule by Machinery.

The *mule* was originally worked by the spinner's hand; but in the year 1792, Mr William Kelly of Glasgow, at that time manager of the Lanark mills, obtained a patent for moving it by machinery. But he soon saw, that, in the extended state of the cotton trade, the exclusive possession of this important improvement was not likely to be quietly acquiesced in, and, unwilling to involve himself in the litigation which would have been necessary to defend his privilege, although the undisputed inventor of the process, he allowed every one freely to avail himself of its advantages.

A great object expected to be attained by this improvement in the mule was, that, in place of employing men as spinners, which was indispensable when the machine was to be worked by the hand, children would be able to perform every office required. To give the means of accomplishing this, Mr Kelly's machinery

* A few of Hargreaves's *jennies* are still employed in spinning cotton waste and the low qualities of India cotton, to be used as wefts in the inferior descriptions of cotton cloth.

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was contrived so as to move every part of the mule, even to the returning of the carriage into its place after the draught was finished. But after a short trial of this mode of spinning, it was discovered that a greater amount of produce might be obtained, and at a cheaper rate, by taking back the men as spinners, and employing them to return the carriage as formerly, while the machine performed the other operations. In this way one man might spin two mules, the carriage of the one moving out during the time that the spinner was engaged in returning the other.

Progress of Improvement in Mule Spinning.

Proceeding in this train of discovery, it was next found that it was no longer necessary to confine the mule to 144 spindles, the largest number it had till then contained, for, with the assistance of the mechanical movement, the spinner was able to manage two mules of three or four hundred spindles each, and thus to spin on six or eight hundred spindles, where before he had spun on only 144.

The process of mule spinning continued to be conducted upon this plan till very lately, when several proprietors of large cotton works have restored the part of Mr Kelly's machinery, which returns the carriage into its place after the draught is completed, with the view of relieving the spinner from this operation, and, by lessening the fatigue, of being enabled to employ women in place of men. All that is to be done by the spinner in this case is, with a slight touch of the hand, to shift the band, to allow the carriage to be moved back into its resting position, managing the guide for building the *cop* as this takes place, and regulating and tempering at the same time the motion of the carriage as it recedes.

Stretching.

In addition to the process for preparing the cotton for frame spinning, which has been described, it goes through a farther operation when it is to be spun upon the mule—that of stretching. When fine yarn came to be spun upon the mule, it was found that extending the roves, at once, to a fine thread was a reduction of texture too rapid to admit of the production of a good article, and that an intermediate operation was necessary. This gave rise to the process of stretching, which is performed on a *mule* fitted up for the purpose, which draws the rove another degree finer, without communicating to it such additional twist as might prevent its being extended afterwards into a thread upon the spinning mule. This process of stretching by the mule has been found so much easier and more expeditious than roving by the spinning frame, that it is now employed in preparing for the coarser spinning, and supersedes the frequent repetition of the drawing process.

We have now finished our account of the different machines employed in cotton spinning, and have endeavoured to describe the succession of improvements, which up to this time have been made upon the plan and mode of working them, so as to give some idea of the effect they must have had to increase the quantity of production. But it will not be possible, from the nature of the thing, to exhibit in a similar manner that advance, not less important, which continued to be made in the better construction of the parts of these machines, and in the skill and management of the spinner in working them. By these a progressive acceleration of their movement was rendered practicable, and even after the machine had long been apparently in a very perfect state, the quantity of produce was nearly doubled. Of these we can only give the results.

Twenty-five years ago, the average production of the spinning machinery in Britain was estimated at between six and seven hanks *per* spindle *per* week. Since that time, it has gradually risen, until it has reached an average of twelve hanks. But we know of several works in which eighteen are now regularly produced; and it is the opinion of the best informed spinners, that even this quantity may be greatly increased.

The effect upon the cost of the article from this increase of production was very great, as will be seen by a statement of the reduction of the wages of spinning, and of the sale price of the yarn, which rapidly followed.

Until the cancelling of Sir Richard Arkwright's patent, by which the mule spinner became at liberty to use his improved mode of preparation—the few fine wefts required for the manufacture were spun on Hargreaves's *jenny*. In the year 1786, this yarn was sold in Glasgow and Paisley at 31s. the pound, for No. 90, 7s. *per* pound being the price of spinning it. The warp was spun upon the twist frame, and was sold at the same time at 47s. 6d. the pound, for No. 90.

We have learned from Mr Crompton, that, immediately upon his completing his invention of the mule, in the year 1775, he obtained 14s. *per* pound for the spinning and preparation of No. 40; that a short time after, he got 25s. *per* pound for the spinning and preparation of No. 60, and that he then spun a small quantity of No. 80, to show that it was not impossible, as was supposed, to spin yarn of so fine a grist; and for the spinning and preparation of this he got 42s. *per* pound.

For some little time after the mule came into general use, in the year 1786, it was the practice in many places for the spinner to purchase the wool in a prepared state, and separate concerns for preparing cotton were established and carried on. At this time (1786) 10s. *per* pound were paid for spinning No. 100, but soon after, the wages for this number were reduced, first to 8s., and then to 6s. 8d. In 1790, the price of spinning No. 110 was 4s. *per* pound. In 1792, it was brought to 3s. 1d., and in 1793 to 2s. 6d., at which price it continued till 1795, when the mule coming to be worked by machinery, and an enlargement of the number of spindles taking place, the spinner was enabled so to increase the quantity of his produce as to admit of another considerable reduction in wages. The price of spinning No. 100 was in the course of a few years brought down to 8d. *per* pound, at which rate it now continues. Notwithstanding this extraordinary diminution of the price of spinning, such have been the effects of the improvements in the plan and construction of the machinery, in the selection and preparation of the wool, and in the spinner's skill and tact in the execution of his work, that he is able to earn more money

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now, than he did when the wages were at the highest.

The sale prices of the yarn during this period were as follows :

In the year 1786	for No. 100	38s.
1787	- -	38s.
1788	- -	35s.
1789	- -	34s.
1790	- -	30s.
1791	- -	29s. 9d.
1792	- -	16s. 1d.
1793	- -	15s. 1d.
1794	- -	15s. 1d.
1795	spun from Bourbon cotton wool -	19s.
1796	ditto	19s.
1797	- -	19s.
1798	*per* Sea Island	9s. 10d.
1799	- -	10s. 11d.
1800	- -	9s. 5d.
1801	- -	8s. 9d.
1802	- -	8s. 4d.
1803	- -	8s. 4d.
1804	- -	7s. 10d.
1805	- -	7s. 10d.
1806	- -	7s. 2d.
1807	- -	6s. 9d.

Since which time, the price has been as low as 4s. 5d., and fluctuating between that and 6s. 9d. But the benefit of the improvements we have noticed, has not been confined to the reduction of the cost of the yarn ; its quality has been rendered so much superior, that the weaver is enabled, without any additional hours of labour, to earn nearly as much as he did twenty-five years ago, although paid a fourth less *per* yard than he was then.

Account of the Progress made in the Cultivation of Cotton Wool.

In an account of the means which contributed to the production of these results, we must not omit the progressive improvement in the cultivation of the raw material, and in the application of its different qualities to their most profitable uses. Previous to the year 1793, the cotton used in the coarser articles of the manufacture, with the exception of a small quantity imported from India, and from the Levant, for the fustian trade, was wholly of the growth of our own, and of the French West India Islands. That for the better kind of these goods was raised in Demerary, Surinam, and Berbice. The wool for the fine goods was grown in the Brazils, and that for the few very fine muslins then manufactured, in the Isle of Bourbon.

In the year 1787, the descriptions of cotton imported into Britain appear to have been as follows.

From the British West Indies -	6,800,000 lbs.
The French and Spanish Colonies - -	6,000,000
The Dutch - -	1,700,000
The Portuguese -	2,500,000
The Isle of Bourbon by Ostend	100,000
Smyrna and Turkey -	5,700,000
	22,300,000 lbs.

Had we continued to be confined to these countries for our supply of cotton, the progress of the manufacture would have been greatly retarded, from the difficulty which would have been experienced in making the production of the raw material keep pace with the increasing consumption ; and, added to this, we might not have been able to obtain the qualities of wool, suited to the finer descriptions of goods, which the improved state of the machinery now enabled us to undertake.

But fortunately about the year 1790, the planters in the southern states of the American union, began to turn their attention to the raising of cotton wool, and, besides carrying the cultivation of the article to a great extent, they produced qualities of cotton before unknown. In the year 1792, the quantity of cotton exported from the United States was only 138,328 libs. At present the annual export is supposed to be not less than 60,000,000 of libs., and the amount is yearly increasing.

The American cotton wool first brought to this country was very ill cleaned, and, in consequence, was for some time indiscriminately applied to the manufacture of the coarser species of goods. It was soon, however, perceived that the cotton grown upon the coast, termed *Sea Island Cotton*, had a finer and longer staple than that grown farther back in the country, and known by the name of *Upland Cotton*. But it was not for several years, and after a succession of trials, that this wool was ascertained to be of a quality in every respect superior to the cotton of the Isle of Bourbon. Indeed, it was not before the year 1796, that the finest description of it was applied to the purposes for which Bourbon wool had till then been used, and which it soon entirely supplanted ; the second quality of it, in like manner, supplanting the Brazil wool, in many kinds of goods for which it had been employed.

The upland cotton is a different species from the sea island, and is separated with such difficulty from the seed, that the expence of cleaning this wool must have put a stop to its farther cultivation, had not Mr Eli Whitney, a gentleman of the State of Massachusets, in the year 1795, invented a machine by which the operation is easily and successfully accomplished.

There are two qualities of this cotton, the one termed upland Georgia, grown in the States of Georgia and South Carolina, and the other, of superior quality, raised upon the banks of the Mississippi, and distinguished in the market by the name of New Orleans Cotton.

There was at first a strong prejudice against this wool ; it was supposed that it was of an inferior quality, and did not receive a good colour in dyeing ; but being found suitable to different coarse fabrics, its cultivation was so rapidly extended, that, in the year 1807, 55,018,448 lbs. of upland cotton were exported from the United States.

The cotton of the finest quality ever brought to the English market, or probably ever grown, was that raised in the Island of Tobago, upon the estate of Mr Robley, between the years 1789 and 1792. That gentleman carried the cultivation of this article to some extent, but the price of cotton falling very

low, and the growing of sugar becoming extremely profitable in consequence of the destruction of the sugar plantations in the French islands, he was induced to convert his cotton plantation into a sugar one. The production of cotton of this description was never attempted by any other person, although it is believed that the price it would yield would amply repay its expence.

Until lately, it was thought that the cotton wool of India, from the shortness of its staple, could not be spun to advantage upon our improved machinery, and, in consequence, the greater part of the Indian cotton brought to this country was spun upon the common *jenny*, and used as weft for the coarsest calicoes. A part of this wool still continues to be thus applied, but a great proportion of it is now mixed with the longer stapled wools of other countries, and by that means brought into a state fit for the mule and spinning frames. It is to be expected that more pains will now be bestowed upon the culture of this article in India than has hitherto been done. The opening of the trade will introduce competition, and the planter will find that a better quality will command a proportionally higher price. The impolitic regulations, however, established under the monopoly for securing the collection of the revenue, and preserving the exclusive trade, being in many places still allowed to exist, retard that improvement which otherwise would take place.

The influence of this policy is particularly felt in the Presidency of Bombay, till lately the only part of India from which any considerable quantity of cotton was exported, and in which the cultivation of this product is so extensive that, in the district of Guzzerat alone, 100,000 heavy bales are annually produced.

About 18,000 bales of this quantity go to the Company for the rent of their lands, and are delivered by the cultivator to the Company's collector, immediately after the cotton has been picked, but before it has been separated from the seed. This person fixes, annually, the rent which the cultivator is to pay; the amount is always imposed in a specified sum of money, but payable in cotton, rated at a price named by the collector. Its amount, upon an average of years, is about one half of the crop. In the payment of this rent, the collector refuses to receive any but the best and cleanest of the cotton; and to this the farmer dare not object. The remaining half is purchased by the Company's commercial Resident, who, till within the last two years, fixed the price he was to give for it. But in the bargains made by this officer, in the last and present year (1818), he has agreed to give to these parties the average price received by the cultivators in the surrounding districts.

If the culture of cotton in the Guzzerat has been able to exist under this oppressive system, what might not be expected, were the rent of the lands, as is now the case in the Presidency of Bengal, permanently fixed, and paid in money; and were the growers at liberty to sell the product to those who would give the best price for it? The rapid increase of cultivation in Bengal, since the introduction of this more enlightened system of management, and the acquisition and diffusion of wealth which have been the consequences, present a striking contrast to the impoverished and wretched state of the cultivators in Bombay, and speak a language in political science, not to be misunderstood.

The Company, within the last two years, have been attempting to introduce the Bourbon seed into the Guzzerat. This plant takes three years to come to maturity; and in the second year of its growth, the crop did not promise well. It would be wrong, however, to be discouraged by the failure of an undertaking carried on under the management which usually belongs to monopoly: For, when that system and its effects shall have been more completely done away, and improvements come to be conducted by those who are to reap the benefit of them, a very different result may be looked for. Were this better system once established throughout the Peninsula, it appears not unreasonable to expect, in a country of such various soil, and of such extent, with a population such as India affords, that not only all the qualities of cotton wool, known to our manufacturers, might be produced, but that new descriptions of it might be obtained, possibly of more useful application than any we yet possess.

The following Table shows the Descriptions of Cotton annually imported into Britain since the year 1802.

	1802.	1803.	1804.	1805.	1806.	1807.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.
American,	107,494	106,831	104,103	124,279	124,939	171,267	37,672	159,980	243,963	128,192	95,331	37,720	48,853	203,051	166,077	199,669
Brazil,	74,720	76,297	48,588	51,242	51,034	18,981	50,442	140,927	142,846	118,514	98,704	137,168	150,930	91,055	123,450	114,518
East India,	8,535	10,296	3,561	1,983	7,787	11,409	12,512	35,764	79,382	14,646	2,607	1,629	13,048	22,357	30,670	120,202
Other sorts,	90,634	45,474	86,358	75,116	77,978	81,010	67,512	103,511	92,186	64,879	64,563	73,219	74,800	52,840	49,235	44,872
Packages,	281,383	238,898	242,610	252,620	261,738	282,667	168,138	440,382	561,173	326,231	261,205	249,536	287,631	369,303	369,432	479,261

The succeeding Table shows the Application of the Cotton imported into Britain in the year 1817.

Stock in the ports, 1st Jan. 1817,	76,600		Export to Continent, 23,300—Ireland, 3,400,		26,700
Ditto in the dealers' hands,	20,000		Taken for consumption of England and Scotland from ports, -	416,300	
Ditto in the spinners' hands, England,	17,000		Deduct increase of stock in the hands of dealers and spinners,	9,300	
Scotland,	2,000		Consumed in England 359,400, or 6911 bags *per* week, Ditto - Scotland 47,600, or 915 bags *per* week,		407,000
		115,800	Remaining on hand in the ports,	112,800	
Import in 1817, - -		479,261	In dealers' hands, - -	28,300	
			In spinners' ditto, England, about 18,000—Scotland 2200, -	20,000	
					161,300
		595,000			595,000

The average weight of the packages included in the import and stock in the ports is 275 libs. The average weight of the package of the cotton consumed in the year is 268 libs.

In these results, we see the necessities, the interests, and the energies, of a free people, calling into existence the latent powers of the cultivator and the mechanic, and co-operating with commerce, in carrying the arts to a degree of perfection which they could not otherwise have attained.

Mr Watt applies the power of the Steam-Engine to manufacturing machinery.

During the time that the machines for the different processes of cotton spinning were advancing towards perfection, Mr Watt had applied his admirable improvements on the steam-engine to the giving motion to mill-work in general. His inventions for this end, besides the ingenuity and beauty of contrivance which they possess, have had an influence upon the circumstances of this country and of mankind, far more important that that produced by any of the other mechanical discoveries which mark this period.

If we had had no other alternative in the means of giving motion to our machinery, than that of placing it on a stream of water, or employing the power of horses, how comparatively expensive must our operations have been, and how slow and limited their progress! By Mr Watt's inventions, we became enabled to carry the power at once to the situation where it could be most advantageously used, to place it in the centre of a population trained to manufacturing habits; and thus to bring together the different branches of manufacture, dependent upon, or intimately connected with each other, with all their numerous subsidiary establishments; thereby giving facility and effect to their mutual operations.

Some account of the introduction of this valuable accessory, naturally forms a part of the history of the cotton manufacture; and, in perusing the following short detail, the reader will be surprised at the slowness with which the steam-engine came into use at first, compared with its present extensive employment.

Mr Watt had early turned his thoughts to the application of the steam-engine to rotative motions; and, in the year 1781, had completed the means for accomplishing this end. But, at the moment he was taking measures for securing to himself the advantages of his discovery, a confidential workman betrayed a part of his invention to other persons, who took a patent for it.

It was not till the following year, after having substituted a most ingenious contrivance to supply the part of the process which had been stolen from him, that he obtained for Messrs Bolton and Watt a patent for the application of this power. Their first *rotative engine* (for we are obliged to use that phrase to avoid circumlocution) was erected in the year 1782, at Bradley Iron Works, and they erected another the same year at their own manufactory. In 1783, they erected an engine for winding ores out of a mine in Cornwall. In 1784, one for an oil mill at Hull, and the first engine for that splendid establishment the London Albion Mills; one at Messrs Goodwin and Company's brewery in London, and one at Mr Whitbread's, with three others, making in all seven engines that year. Among those erected by them in 1785, was one for Messrs Robinsons at Papplewick, in Nottinghamshire, for spinning cotton, the first instance of the application of steam to this manufacture. In the following year, they erected a number of rotative engines for various purposes; and, in 1787, one for Messrs Puls at Warrington, for cotton spinning, and three others for the same purpose at Nottingham. But no rotative engine had yet been erected at Manchester; and it was not until 1789, seven years after Bolton and Watt had received their patent, that they constructed, for Mr Drinkwater, the first engine used there in spinning cotton. In 1790, they erected one for spinning cotton at Nottingham, for Sir Richard Arkwright, and another at Darlington for spinning flax; a cotton spinning engine at Manchester, for Mr Simpson, and a second one at Papplewick, for Messrs Robinsons. Some time before this, however, Sir Richard Arkwright and others, from an ill-judged economy in the first cost, had used, for spinning, atmospherical or Newcomen's engines, with rotative motions applied to them. But, soon coming to see their error, these were abandoned, and Bolton and Watt's engines came into general use with the cotton spinners, and in all other manufactures where this power was to be employed.

About the year 1780, some attempts began to be

First attempts to manufacture Muslins.

made, both in Lancashire and at Glasgow, to manufacture muslins, but without success. There was no yarn for the weft of these goods, but that spun upon Hargreaves's *jenny*, and when made of this, it was found they were not of a marketable quality. The next attempt was with wefts brought from India, and although a better article than the former was by this means produced, it was still not of a quality to bear competition with Indian muslin.

It was not till the mule *jenny* gave the yarns suited to the fabrics, that the manufacture of the finer cotton articles had any success in this country. This machine, as has been mentioned, came into use at the end of the year 1785, upon Sir Richard Arkwright's patent being cancelled, and it is from this period that we are to date the proper commencement of this part of the manufacture. So rapid, however, was its progress after this time, that, in the year 1787, 500,000 pieces of muslin, it was computed, were manufactured in Great Britain.

This article began to be made nearly at the same time at Bolton, at Glasgow, and at Paisley, each place betaking itself to the fabric which resembled most the goods it had been accustomed to manufacture; and, in consequence of this judicious distribution at first, each place has continued to maintain a superiority in the production of the articles it set out with.

Jaconets, both coarse and fine, but of a stout fabric, checked and striped muslins, and the other articles of the heavier description of this branch, are manufactured at Bolton and in its neighbourhood.

Book, mull, and lino muslins, and jaconets of a lighter fabric than those made in Lancashire, are manufactured at Glasgow. Sewed and tamboured muslins are almost exclusively made there and at Paisley. A machine, of most ingenious contrivance, for performing the operation of tambouring, was, about ten years ago, invented by Mr John Duncan of Glasgow, and a patent taken out for the discovery. Each machine contains about forty tambouring needles, and is superintended by a girl, who pieces the thread when it breaks. The patent is at present the property of the Messrs Mitchells of Glasgow, who have a work containing twenty-one of these machines.

What are called fancy goods, wove in the loom, were first made at Paisley, which had been the chief seat of the silk gauze manufacture of this country. In this branch, which was beginning to fall into decay, a body of most ingenious workmen had been bred, and by employing them, the taste and invention which had produced the varieties displayed in that beautiful article, were immediately transferred to the production of similar descriptions of muslin. From this circumstance, Paisley, for a long time, retained the exclusive possession of this branch; but being only seven miles distant from Glasgow, the general seat of the cotton manufacture of Scotland, and the mart to which most purchasers resort, several of its principal manufacturers were induced to move their establishments to that city, although the weaving of these muslins continues to be executed in Paisley or its neighbourhood. The weavers employed on this article, supposed to amount to above five thousand, are probably the most orderly and the best informed body of workmen to be found in the island. Their occupation happily is of a nature to afford exercise to their minds, and having received the education given to this class in Scotland, they are not only fond of reading, but there are among them many with considerable literary attainments, and some who devote their spare hours to the prosecution of science. If it were required to prove the beneficial effects produced upon the condition of the lower orders by education, and the cultivation of the understanding, the superior state of the working people of Paisley above that of most other places might safely be referred to.

There is a curious circumstance to be noticed with regard to the manufacture of fine muslins in Scotland, that nearly the whole of the yarn used for this article is brought from Manchester, in consequence of the Scotch spinners not having yet been able to produce fine yarn of the best quality. This inferiority does not proceed from a less perfect construction of the machinery employed in Scotland, the mechanics and machine-makers of Glasgow being admitted to be excellent workmen; neither does it arise from the want of skill in those who conduct the business, or from any difference in the processes employed in the two countries; but it is to be attributed to the same cause which produces the superior yarn of India; namely, an adroitness and mechanical slight of hand, in the operative spinners, acquired by a few out of the great multitude bred at Manchester.

The manufacture of the thicker cotton fabrics was at the same time rapidly extending. The manufacture of dimities has been exclusively confined to the north of England, all attempts to make them in Scotland having proved unsuccessful. The finer qualities of this article are made at Warrington, the coarser in the western parts of Yorkshire.

Balasore handkerchiefs were at this time begun to be manufactured about Preston and Chorley, where they still continue to be made.

The manufacture of ginghams was for a long time confined to Lancashire, but for many years it has been extensively introduced at Glasgow, although Lancashire continues to be the chief seat of this branch.

Pullicat handkerchiefs were begun to be made about the year 1785 at Glasgow, where the manufacture of them has been carried to a great extent. They were not made in Lancashire till some time after, and the manufacture of them there has never been to the same amount. Glasgow therefore continues to be the principal mart for this article.

Blue and white checks and stripes for exportation, were at first a linen fabric; afterwards they were made with linen warp and cotton weft; and when Sir Richard Arkwright's discovery enabled the spinner to produce cotton yarn of a sufficient strength, to be used for warps, a great proportion of these goods came to be made wholly of cotton. This manufacture is carried on in Lancashire and in the county of Fife, and to a small extent at Aberdeen; but the chief seat of this branch is at Carlisle.

The manufacture of cotton cambric was begun

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about the same period, and was separated into two branches: into cambric to be used as garments in a white or printed state; and into cambric made in imitation of French linen cambric, to be used for the same purposes with that article. The first is manufactured nearly altogether in Lancashire, where it is carried on to great extent, and the second, of much less amount, wholly at Glasgow; the Scotch manufacturers having never been able to rival the Lancashire in the first, nor the Lancashire manufacturers to rival the Scotch in the last.

Bandanna handkerchiefs, and bandanna cloths for garments, were begun to be made at Glasgow about the year 1802, by Mr Henry Monteith, and are now manufactured there to a considerable amount. The cloth is dyed a bright Turkey red, and the colour is discharged from those parts in it which form the pattern or figure, by passing a chemical mixture through them. This article is made no where but at Glasgow.

From Glasgow being the seat of a fine manufacture, it was not found practicable to introduce there the making of calicoes. This article, however, was made at Perth, though never to a great amount, and the Scotch printers were obliged to get the principal part of their supply from Lancashire. In this state, they felt that they were not on an equal footing with the English printers, and as large capitals had been embarked in the trade, there was a considerable anxiety that this defect in their situation should be remedied. This was at last accomplished by the introduction into Scotland, in the year 1801, of the art of weaving by the power of water or of steam, the machinery and subsidiary processes for which had about this time been so improved, that the cloth woven in this way was found to come as cheap, if not cheaper, than that derived from manual labour.

Weaving by the power of Water or Steam.

Mr Cartwright's Invention.

Weaving by water or steam had been attempted fifteen years before that period by the Rev. E. Cartwright, of Hollander House, Kent, who invented a loom to be worked by mechanical means. The circumstances of this discovery, which have been obligingly communicated to us, in a letter from Mr Cartwright, are curious, and in the history of inventions, we think interesting. Mr C. says,

"Happening to be at Matlock in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed, that as soon as Arkwright's patent expired, so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation I replied, that Arkwright must then set his wits to work to invent a weaving mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I certainly was incompetent to answer, or even to comprehend, being totally ignorant of the subject, having never at that time seen a person weave. I controverted, however, the impracticability of the thing, by remarking that there had lately been exhibited in London an automaton figure which played at chess. Now, you will not assert, gentlemen, said I, that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.

"Some little time afterwards, a particular circumstance recalling this conversation to my mind, it struck me, that, as in plain weaving, according to the conception I then had of the business, there could only be three movements, which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail-cloth is usually made of. To my great delight, a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to any thing mechanical, either in theory or practice, nor had ever seen a loom at work, or knew any thing of its construction, you will readily suppose that my first loom must have been a most rude piece of machinery. The warp was placed perpendicularly, the reed fell with a force of at least half a hundred weight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent, 4th April 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment, when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom, in its general principles, nearly as they are now made. But it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st of that year."

But the idea of weaving by machinery was not new. About the close of the preceding century, a drawing and a description of a similar loom (a circumstance unknown to Mr Cartwright) had been presented to the Royal Society of London. The movements, too, in both, are the same with those of the Inkle loom, a machine which had long been in use.

Mr Cartwright, after obtaining his second patent, erected a weaving mill at Doncaster, which he filled with looms. This concern was unsuccessful, and at last was abandoned. But still the invention was considered so important to the country, that some years after, upon an application from a number of manufacturers at Manchester, Parliament granted Mr Cartwright a sum of money as a remuneration for his ingenuity and trouble.

About the year 1790, Mr Grimshaw of Manchester, under a licence from Mr Cartwright, erected a weaving factory, which was to have contained five hundred looms, for weaving coarse sacking cloth. He was also to have attempted the weaving of fustians. But after a small part of the machinery had been set agoing, the work was destroyed by fire;

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and the concern, during this trial, not having promised to be successful, the mill was not rebuilt.

About the year 1794, Mr Bell of Glasgow invented another loom, for which a patent also was taken, and a factory of these looms was erected at Milton, near Dumbarton. But this concern, although carried on for many years, was not more successful than those which had preceded it.

In the year 1801, Mr John Monteith of Glasgow erected a weaving factory, containing two hundred looms. This also was at first unprosperous, but, for a considerable time, it is supposed to have been successful, the number of looms, some years ago, having been increased to three hundred.

In 1805, a large weaving mill was erected at Catrine, in Ayrshire, by Messrs James Finlay and Company, to be carried on in conjunction with their extensive spinning work at that place; and, in 1808, they built another mill at Down, in Stirlingshire, connected with their spinning works there: the two containing 462 looms. The quantity of cloth produced in these establishments, in proportion to the number of hands employed in them, is understood to have been greater than had been obtained before in other works, and the undertaking is said to have done well from the outset.

After this period new weaving factories were reared in Glasgow or in its neighbourhood, almost every year; and it would appear that this branch is now solidly and permanently established in that part of the country. At present there are in Glasgow, or belonging to it, fifteen weaving factories, containing 2275 looms, and producing about 8000 pieces of cloth weekly.

In the present improved state of this process, one person, generally a girl, attends to two looms, the weekly produce of which is from seven to nine pieces of cloth of $\frac{7}{8}$ths wide, and 28 yards long, woven in an 11^{00} reed. For this she is paid at the rate of 1s. 2d. *per* piece.

Mr Ratcliffe's Dressing Machine.

This mode of weaving, however, never could have succeeded, and indeed must have been long ago abandoned, if Mr Ratcliffe, of Stockport, had not happily invented a process for dressing the web before it is put into the loom. The stoppage of the work from time to time, which made it impossible for one person to do more than attend to one loom, was thus rendered unnecessary.

The contrivances for performing this process are very ingenious, the machinery employed in it having its movement from the power which gives motion to the looms.

The yarn is first wound from the cop upon bobbins, by a winding machine, in which operation it is passed through water to increase its tenacity. The bobbins are then put upon the warping-mill, and the web warped from them upon a beam belonging to the dressing frame. From this beam, placed now in the dressing frame, the warp is wound upon the weaving beam, but, in its progress to it, passes through a hot dressing of starch. It is then compressed between two rollers, to free it from the moisture it had imbibed with the dressing, and drawn over a succession of tin cylinders heated by steam, to dry it; during the whole of this last part of its progress being lightly brushed as it moves along, and fanned by rapidly revolving fanners.

The weaving of calicoes by *power*, has not succeeded so well in Lancashire as in Scotland, although numerous attempts, some of them on a considerable scale, have been made to establish it there. They have never at any time had more than two thousand of such looms at work; the number employed at present does not exceed a thousand; and without some change of circumstances, it is thought that even these must be given up.

The obstacle to the success of this branch in Lancashire, seems to be the low wages at which goods are woven there by the hand. The population of this district, it appears, has reached an amount which makes it press at all times on the means of employment, and when trade is dull, to a great degree. Whenever trade, therefore, is in this state, the price of hand-weaving falls below what the goods can be produced for by machinery, making an allowance for its cost and maintenance. But there is besides another thing which, at times, helps to bring the goods produced by hand-weaving, particularly those of the lowest quality, cheaper to market than those from the power looms, namely, that yarns of inferior description, and bought at a lower price, can be used by the hand weaver, and by great dexterity and pains, fabricated into marketable cloth. This cannot be done in machinery, the yarn for which, that it may stand the fatigue of the operation, and occasion as few interruptions as possible by breaking, must be spun from a superior quality of wool, and with more than ordinary pains, and in consequence is dearer than even the best yarn used for cloth woven by the hand. From these circumstances operating in favour of the production of goods by hand-weaving, the attempts to extend weaving-mills have not proved successful in Lancashire. But this struggle between the two processes, we think, must finally terminate in favour of the latter. For the weavers cannot go on at the wages they have been reduced to, while the weaving-mills, if we may venture an opinion from what we have seen take place in other processes of machinery, will be daily acquiring facilities and improvements, in addition to the advantages which they already possess. Until, however, the demand for labour increases, the lower qualities of goods will probably continue to be woven by the hand, while those of a superior quality, requiring better materials, will be woven by machines.

Mr Peter Marsland, of Stockport, who, for many years, has had a large factory for weaving cloth of a superior quality, is the inventor of an improvement upon the *power* loom, by means of the double crank, for which, about ten years ago, he obtained a patent. The operation of this crank is to make the lathe give a quick blow to the cloth on coming in contact with it, and thereby to render it more stout and evenly.

From the change which has lately taken place in the dress of this country, by the printed cotton cloths being nearly supplanted by silks and worsted stuffs, it has been supposed, that the manufacture of calicoes, and in general of cotton goods, must have considerably declined. This, however, is not the

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case. The increased demand for this article for exportation, to be printed abroad, or used there in a white state, has more than compensated the falling off in the sale for the home printing trade; and the number of yards of cotton cloth of this description, produced at present, is greater than it was when printed cottons were universally worn.

General run of the present amount of the Cotton Manufacture of Britain.

Having now brought down the history of the cotton manufacture of this country to the present time, we shall endeavour to give a view of its progressive advances from time to time, from a statement of the quantity of cotton wool imported into Great Britain at different periods.

From the year 1716 to 1720 the average annual importation of cotton was 2,173,287 lbs. We have not been able to obtain any account of the cotton imported from this period to the year 1771; but the increase above the preceding importation had not been great; for the average annual importation from 1771 to 1775, which commences two years after Hargreaves's and Arkwright's discoveries, and comprehends two years of the time after which calicoes began to be made wholly of cotton, is only - - - 4,764,589 lbs.

From 1776 to 1780	it was	6,766,613
1781 to 1785	——	10,941,934
1786 to 1790	——	25,443,270
1791 to 1795	——	26,000,000
1796 to 1800	——	37,364,077
1801 to 1805	——	58,334,492
1805 to 1810	——	76,601,775
1811 to 1815	——	71,761,067
1816	——	93,920,055
1817	——	124,996,427

The present annual value of the cotton manufacture of Great Britain, is estimated to be between thirty and forty millions of pounds sterling: of which there is exported, including cotton yarn, to the value of twenty millions sterling. Of this last article, there was exported in 1816, 16,362,782 lbs. valued in the custom-house entries at L. 2,707,384. *

In the year 1811, when Mr Crompton applied to Parliament for a remuneration for his invention, he found the number of mule spindles in the country, by as accurate an investigation as he could make, to be about five millions. At present the number of spindles, throstle and mule, is supposed to be nearly six millions; and the power required to move them, it is calculated, is equal to that of 10,572 horses.

Such is the state to which we have been enabled to bring this manufacture, in consequence of the inventions of Hargreaves, Arkwright, Crompton, Kelly, and Watt. But having reached this point, it may be asked what security we have that we shall be able to retain this branch to the same extent, now that other countries, over which we possess no exclusive natural advantage, are using efforts to participate in its benefits. To this it can only be answered, that the hopes of being able to preserve our hold of this manufacture, rest upon our persevering industry, our economy, our great capital, the advanced state of our attainments in machinery and mechanical knowledge, and the advantage we derive from having been long in possession of the business, and by that means being more skilful in the manipulation, and better acquainted with the minutiæ of its processes. The start we have got of our competitors in the career of invention and discovery is another important advantage. The lead we have thus obtained, we think it probable we may be able for a long time to retain; for invention is progressive, and, in a manufacture extended like ours, it is at the same time diffusive; every discovery that is made, having the effect to unfold principles leading to other discoveries, or to suggest analogous applications in other departments. And when the manufacturing class has once received this impulse, those who conduct the processes, and those employed in the operative part of them, have their thoughts constantly turned to the means of enlarging the powers of the machines they are in possession of, or to the discovery of other machines for executing work still performed by the hand. But beside the greater progress in machinery, which may be expected to take place in a long established manufacture, there is a progress also of art in the use of that machinery, of contrivance to supply its defects, and of little undefinable subsidiary aids for the furtherance of the work, which contribute to give a superiority to it over every undertaking of a more recent date. † Or, to take a more liberal view of the matter, may there not, independent of these securities, be room for the growth of the manufactures of other countries, without the diminution of ours, in the increased wealth and consumption of all?

But it is not the rivalry of the European states, it is thought, that we have most to dread in this branch. Over many of them we have natural advantages, and with all of them, from the circumstances which have been stated, it is probable we shall be able, if necessary, to maintain our ground. But this, it is feared, may not be the case to the same degree, in the competition which at some future period we shall

* By a computation, from data collected with great care, it appears, that in the year ending the 1st of May 1818, there were 105,000,000 of yards of cotton cloth of all descriptions manufactured in Glasgow and the neighbourhood, the value of which was estimated to be L. 5,200,000, and that of these goods about one half was exported.

† When the measures for conciliating the respective commercial interests of parties in the Irish union were arranging, the opinion of professional men was taken as to the period at which the cotton manufacture of Ireland might be able to go on in competition with that of England without the help of protecting duties; and Mr William Orr of Dublin, who had introduced the manufacture into that country, was asked if he thought it likely that in ten years the Irish manufacturers would overtake the English in skill. Mr Orr replied, yes! if the English can be persuaded during that time to stand still.

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have to encounter from America; after her great tracks of land are occupied, and a fuller population admits of her capital and industry being profitably directed to manufacturing pursuits. From being the grower of the raw material, it is apprehended she will have an advantage over us in this contest which none of our other competitors possess. But even this circumstance, we apprehend, is not of so much moment as at first sight it may appear. The southern states of the union, in which the cotton wool is raised, from their local defects in other requisites, and the description of people of which their lower order is composed, never can become a manufacturing country. The competition, therefore, which we shall have to sustain, will be with the people of the northern states, who must, like ourselves, import the raw material they are to manufacture. The difference of its cost to them and to us cannot be great, particularly if we shall have the East Indies and South America open for our supply.

We believe, then, that in this manufacture we have little to fear from a competition with others; but we are not equally confident that its prosperity may not be exposed to risk from our ill-judged anxiety to secure a monopoly of its advantages. Our practice of excluding from our markets the manufactures of other countries, is not only contrary to sound commercial principle, but gives rise to a spirit of hostility unfavourable to our interests, and places us in that state, that when other nations, in retaliation, exclude our manufactures from their markets, we have no right to complain. But even without any wish to retaliate, will not the different nations, as they advance in manufactures, be led to copy regulations to which they may erroneously ascribe our success?

That we may not decide this question rashly, let us examine what is the danger we should be exposed to if we were to take the opposite system, and open our ports to the manufactures of other countries.

If we can now export annually to the value of twenty millions Sterling of cotton goods, which, burthened with freight, charges, and the exporters' profit, we are able to sell in competition with the foreign manufacture, can we have any thing to fear from a competition with that manufacture in our home market, where the circumstances of the competing parties will be reversed? So far from the introduction of foreign manufactures into our market being an evil, we are inclined to think that it would be advantageous to our interests; that in the interchange of commodities which would be the consequence, the sale of our own manufactures would be increased. Commerce being altogether a matter of barter, it is necessary for every country to purchase, in order that she may sell. And, fortunately, even in the same branch of manufacture, there is always room for such exchanges. There are shades of difference in the fabric of every article, upon which fashion or caprice never fails to fix an arbitrary value, thereby constituting them into separate commodities capable of being exchanged.

But the view we are taking of this important question does not rest altogether upon theory. Happily we have experience in support of it. No one disputes the advantage resulting from the interchange of commodities between Lancashire and Lanarkshire, or alleges that it would be for the benefit of either to have the manufacture of the other excluded from its market; yet these two districts have their dependence upon manufactures, which, in their general features, are the same.

Those, who recollect the commercial treaty with France, in which some approach was made to a free trade between the two countries, will remember, that while it lasted, the sale warehouses of London and Manchester were resorted to by the purchasers from the different towns of France, with the same freedom, and in nearly an equal proportion of numbers, as from the towns in England. And although in those warehouses, commodities of a similar description, of French and English production, were to be found, and our shopkeepers were at the same time daily resorting to France to make purchases, in no period were our manufactures in a state of greater progressive prosperity, than during the six years, from 1786 to 1793, that this treaty existed. There is no one, we believe, who had an opportunity of knowing the two countries at the time we mention, who will not say, that both were benefited by this treaty, and, probably, exactly in the degree that the exclusive system in both had been departed from. In addition to this, it may be proper to notice, that Switzerland and Saxony have always been open to the reception of cotton goods, free of duty; and that in none of the countries on the Continent is the cotton manufacture in a more thriving state. Might it not, therefore, be a measure of wisdom, to withdraw our restrictions against the importation of foreign manufactures, the interference of which with our own products in the home market, supposing no interchange of the two to take place, never could be to the amount of the sale we may be deprived of by following the opposite policy, and thus inducing the exclusion of our own goods from the foreign market?

Before concluding our account of the cotton manufacture of this country, we shall offer a few observations upon the effects produced, by the extension of the use of machinery, on the character and moral condition of the people.

The more perfect division of labour, and separation of employments, which take place, as the use of machinery advances, and the consequent limitation of the workers' attention to a single object, check the expansion of the faculties, and prevent that growth of intelligence in this class, which, under a more general employment of their powers, might be expected. There is another evil of a similar nature, but attended perhaps with more serious consequences, produced by manufactures when they have arrived at this state, namely, the employment of children in the factories, by which these young creatures are withdrawn from their parents and homes before they have received the elements of education, or can have acquired domestic or moral habits.

In noticing these evils, however, we must recollect, that the state of manufactures which gives birth to them is not an optional one, or the production of

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regulation or institution, but has grown up in the progress of the arts of industry prosecuted by an intelligent people. Although, therefore, it is our duty, in as far as we can, to correct their effects, we must lay our account with being exposed to them, so long as men are allowed to pursue their interests by whatever fair means they conceive likely to attain their ends.

To remedy, in as far as possible, the interruption of education from this employment, there are schools in many of those factories, in which the children are instructed gratis in reading and writing. An establishment of this kind, we conceive it to be the interest of every work to provide. Its expence cannot be great, and will be amply repaid in the superior description of workers it will be the means of rearing. In the mean time, something is done to supply the deficiency of this provision by means of Sunday schools; which have been generally established in most of the larger manufacturing towns. In these, the children are not only taught to read, but also instructed in the principles of religion, and in a knowledge of their moral duties. In the city of Glasgow there are about 5000 children who receive education by this means. And this invaluable blessing is obtained from the gratuitous services of a few benevolent young men, chiefly Methodists, who devote several hours every Sunday to this praiseworthy employment. To each of the Glasgow Sunday schools a juvenile library is attached, supported by a subscription of a penny a month from each child choosing to become a member of it, and conducted by a committee of the children themselves, under the direction of the teachers. The books in these collections are not only read by the children, but by their parents, upon whose habits, in many instances, those means of recreation have been known to have produced salutary effects. *

In Glasgow there is another establishment, intended for the improvement of those who have arrived at a more advanced age, and have received the first rudiments of education. The information given in it we consider calculated to produce the most important effects.

About sixteen years ago, Dr Birbeck of London, then professor of natural philosophy in the Andersonian Institution at Glasgow, planned a course of lectures, upon the principles of mechanics, in the view of instructing the working class there, in the science of their respective occupations; and to render the information he wished to convey to them familiar, he illustrated his prelections by an exhibition of working models of different machines. The lectures were given on the Saturday evening, and for the two first years gratis, a recommendation from some respectable manufacturer being all that was required for admission. Between four and five hundred persons attended each year. Having ascertained the disposition in these people for information, Dr Birbeck thought it proper, in order that a feeling of independence might be kept up in them, to make the terms of admission to the course two shillings and sixpence, to defray the expences of experiments, a sum which the poorest among them could without difficulty command.

The furnishing of these parties with a course of instruction, so well adapted to their circumstances, is probably the best means that could have been devised for reviving the powers which their early occupation in the factories may have rendered torpid. But the benefit to be derived from these lectures, is not confined to the individuals to whom they are delivered. The branches of manufacture in which those persons are employed profit by them also. In the same degree that workmen are made acquainted with the principles of the processes with which they are occupied, will be the probability that improvements shall be introduced. So important, indeed, does the securing of this object appear to us, in the present circumstances of this country, that we think the plan sketched by Dr Birbeck for Glasgow should be generally extended, and our artizans all over the kingdom furnished with the means of receiving similar instruction. Were a national provision made, for giving in all our large manufacturing towns, such lectures upon mechanics, to which might be joined a short exposition of the elements of chemistry, the most important consequences might be expected to ensue. The expence of such an institution would be trifling, while means would be afforded of rearing, in every department of industry, a body of intelligent workmen, qualified to carry forward that progress in machinery which we have shown to be necessary to the prosperity of our existing undertakings.

Cotton Manufacture of Ireland.

Some attempts were made as early as the year 1770 to introduce the manufacture of cotton goods into Ireland, but on a very limited scale before the year 1790. After that period the progress was considerable, although far short of what took place during the same time in this country. Indeed, the cotton manufacture has never arrived at that state in Ireland, that its products could enter into competition with those of Britain, or even become articles of general foreign sale.

The goods manufactured in Ireland are almost

* The plan of discipline followed in some of these schools we think excellent, and worthy of being imitated in what may be considered more important establishments. When faults of carelessness are committed, the party is reprehended or punished immediately by the teachers; but any thing amounting to a misdemeanour, or of the nature of a crime, is brought before a jury of the children, and submitted to their consideration and award. The teachers say, that it is astonishing with what propriety these young jurors conduct themselves on such occasions, the pains they take to investigate the circumstances, and the judgment with which they make up their opinion, and award the sentence. We question if there be any thing taught in these schools of more important influence on the future character, than the moral impression of self respect made upon them by the exercise of these functions.

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entirely for home consumption, and the monopoly of this sale is endeavoured to be secured to its manufacturers, by a duty of ten *per cent.* levied upon all cotton cloths brought into the country. Even with this encouragement, the Irish cotton manufacture does not thrive, and English goods continue to be imported. Perhaps this state of the manufacture may in part be occasioned by the high price of fuel in that country; for, without a command of the power of steam at a moderate expence, the concentration of the several processes, and the consequent saving of labour, are impossible in most situations.

The chief seat of this branch in Ireland is Belfast, and the district of country within twenty miles of that town. But there are a good many calicoes, fustians, and cotton checks, made in Dublin, Balbriggan, Banden, and Cork. All these goods are consigned to factors in Dublin for sale, except a part of the calicoes, which the manufacturers are sometimes enabled to dispose of to printers upon the spot.

There are twenty-five cotton mills in Ireland, containing about 145,000 spindles, partly mule and partly throstle. And when all these are at work, they are supposed to spin about 36,000 lbs. of cotton weekly; but at present a number of them are standing unemployed.

Some of the spinners manufacture the whole of their own yarn, while others do not manufacture any. But in either case the weaving is carried on by capitalists, who give out the yarn to be woven, and pay the weaver wages for his work. The conducting of this business exclusively on this plan appears extraordinary, when it is considered that the greater part of it is carried on in the same district with the linen manufacture, in which the weaver is the sole manufacturer; buying the yarn for his web, and selling the cloth when he has finished it. Perhaps the difference in the manner in which these manufacturing processes are conducted, may proceed from the different way in which the yarns made use of in the two branches are produced. The yarn for the linen manufacture is spun by individuals scattered over the country. This, in the infancy of the business, and while little capital had been accumulated, may have led to the manufacturing process being carried on in a like detached manner; the weaver purchasing the yarn from his neighbour the spinner, and, after converting it into cloth, selling the web at the nearest market to the merchant. The cotton manufacture in Ireland did not grow up thus from small beginnings, but was introduced into that country at once, from England, and with spinning establishments upon comparatively a large scale. It was in consequence necessary that the weaving should, from the first, take off the produce of those establishments; and there being no way of effecting this with certainty, but by employing the weavers upon wages to work up the yarn, the manufacture was begun, and has been prosecuted upon this plan ever since, while the linen manufacture, carried on in the same district, continues to be conducted upon the opposite system.

The annual return of the cotton manufacture of Ireland is estimated at L. 700,000.

Cotton Manufacture.

Cotton Manufacture of France.

The cotton manufacture was introduced into France about fifty years ago, and was first established at Arebonas in the Vivarais, from whence it afterwards made its way to Montpelier in the lower Languedoc. For some time after its introduction the greater part of the yarn used in its fabrics was brought from the Levant, a small part only being produced in the country, and that was spun in the mountains of the Vivarais and the Gevanvans. The Turkey red yarn required for the coloured goods was either brought from Adrianople and Smyrna, in a dyed state, or the manufacturers sent the yarn of their own spinning to these places by way of Marseilles, to be dyed and returned to them. But this circuitous mode of obtaining those yarns did not continue long; for the manufacturers soon succeeded in inducing some Greek dyers to settle in France; and the natives having acquired from them a knowledge of their processes, the whole dyeing required for the manufacture came in the course of twenty years to be executed by Frenchmen. From these yarns, spun and dyed in the way we have stated, were produced at Montpelier, at Cholet in La Vendée, and in Bearn, large quantities of pocket-handkerchiefs, and of cloths for garments, and for furniture. The manufacture of these articles, and the art of dyeing, were established also at Rouen, at Amiens, and throughout the surrounding country, within ten years after their introduction into the south of France. Before this period there had been a considerable linen manufacture carried on at Rouen, and of articles similar to those afterwards made of cotton. The cotton goods, however, as was the case in England, were at first woven with linen warp and cotton weft; and it was not till after Sir Richard Arkwright's invention, that they were able to make them wholly of cotton.

With all this activity in pushing the extension of the cotton manufacture in France, no early attempts were made by the French manufacturers to avail themselves of the improvements, which, during this period, had been introduced into the process of cotton spinning in England. The first spinning machine they had, of a construction superior to the one thread wheel, was a *mule* which Monsieur de Calonne, at that time minister, introduced in the year 1787. This was immediately copied, and these machines adopted wherever the manufacture was carried on. The use of them from this time increased rapidly, particularly at Rouen, at Paris, at Lille, at St Quintin, at Amiens, and at Montpelier. About the same period the first attempt to spin water twist was made at Louviers. Hostility to the introduction of these improvements, similar to what had before taken place in England, was manifested by the common people in France. But the disposition to disturbance was soon quelled, and the evident advantage which the new mode of spinning possessed over the old, put an end in a short time to all idea of opposition.

It is only in the large spinning works, of which there are very few in France, that the power of water or of steam is employed, and even in the greater part of these, the application of these powers is confined to the machinery used in the preparation of the cotton. Nearly the whole of this branch,

therefore, is carried on in France with small systems of preparative machinery, moved by the power of horses, or by a wheel turned by a man or men, and the spinning part, under either system, is almost wholly worked by the hand. The yarn they spin at present is from No. 15 up to No. 150.

The weaving branch is partly carried on by manufacturers, but more generally by operative weavers, who buy the yarn they are to use, and dispose of the cloth when woven at the weekly markets.*

In the plan as well as in the conduct of many of the processes of this manufacture, it is evident that the French are behind the English. And this is particularly the case in the important art of combining mechanical power with manual dexterity, so as to occasion an economy of labour and increase of production. But they will now make every effort to remedy these defects; and as they are an ingenious and industrious people, we must lay our account with finding them at no distant period, in a state to maintain a more successful competition with us.

The French have been induced to prosecute the manufacture upon the plan we have mentioned, rather than with establishments upon the extended scale, and of the comprehensive nature used in this country, by the high interest they are obliged to pay for money, upon the one hand, and the comparatively cheap rate of labour upon the other. The combined operation of these circumstances, led them to the system they have pursued; as being calculated, they conceived, to produce the goods upon the cheapest terms, and with the smallest advance of capital. In the attempts that were made too, in France, during the late war, to introduce our large *power systems*, no saving corresponding to the advance of capital which they required was obtained, and many of the parties who embarked in these undertakings were ruined.

The French now, however, are generally impressed with the advantages we possess over them, from carrying on our spinning in large establishments, moved by mechanical power, and are anxious to adopt the same plan. They have no scarcity of falls of water for this purpose, but the greater part of these are in situations either where the population is scanty, or which are inconvenient for the disposal of the manufactured product. Many of them too are already appropriated to mills and mines, and in consequence not to be obtained but at an expence, which the benefit to be derived could not repay. In their proposed improvements, therefore, they will, in most cases, be obliged to have recourse to steam. They have already (1817) got four spinning works upon an extended scale, with English steam-engines, and more are forming. The ruin which the preceding adventurers had experienced, affords an advantage to their successors, from the cheap rate at which the latter are enabled to purchase the erections formerly made. In these new establishments, they are introducing *mules* of 800 spindles. Upon this change of system,

* For a great part of this account of the cotton manufacture of France, we are indebted to the Count Chaptal, who, upon being applied to for some information on the subject, with a liberality which usually accompanies talents, immediately favoured us with the following details:

" *Amboise, le* 18 *Juin* 1817.

" C'est avec plaisir que je vais vous transmettre les renseignements que vous me demandez.

" Les manufactures de coton ont été introduites en France il y a peu près 50 ans; la première fabrique a été formée à Arebonas dans le Vivarais; de là cette fabrication a passé à Montpellier, dans le bas Languedoc. On tiroit une grande partie du coton filé du Levant, et on filoit le reste au rouet ou à la main dans les montagnes du Vivarais et du Gevanvans.

" Pendant plusieurs années, on tiroit les cotons teints en rouge d'Adrianople et de Smyrne; ou y envoyoit meme par Marseille, des cotons filés pour les y faire teindre.

" Quelques années après, on a attiré dans le pays, des teinturiers Grecs qui, peu apres, ont fait connoitre leurs procedés, et depuis 30 ans il n'y a que de Francais qui teignent.

" Avec ces cotons on fabriquoit à Montpellier, à Cholet dans la Vendée, et dans le Bearn, des tissus pour habillement, meubles, mouchoirs, dont il se faisoit un grand commerce.

" Le fabrication de ces tissus, et l'art de la teinture ont été etablis à Rouen, à Amiens, et dans tous les environs, 10 ans après qu'ils existoient dans le midi de la France.

" Le ministre Monsieur de Calonne a introduit le premier metier pour filer le coton, il y a 30 ans. Depuis cette epoque, et surtout depuis 20 ans, ces mechaniques se sont propagées sur tous les points de la fabrique, surtout à Rouen, à Paris, à Lille, à St Quintin, à Amiens, à Montpellier. Elles sont si nombreuses que, d'apres un calcul exact, elles peuvent filer 30,000,000 de livres pesant par an, de laine de coton. Elles sont mües par des cours d'eau, par des chevaux, ou par des machines à vapeurs.

" Le tissage se fait dans les villes, et dans les campagnes. Il y a beaucoup de tisserands qui achetent leurs fils et vendent leurs tissus aux marchés où se vendent les fils. Il y a des entrepreneurs qui donnent le fil et font tisser *à savoir*.

" On fabrique en France toutes sortes de tissus de coton; à Tarrare, et dans les montagnes voisines, on fait des mousselines qui ne le cedent pas aux plus belles des Indes. Nos imprimeurs sur toile n'employent que les calicos et les percales fabriqués chez nous, et ils y trouvent de l'avantage.

" Le commerce des tissus de coton fabriqués chez nous, est annuellement de deux à trois cents millions de francs, sur les quels il y a les quatre cenquièmes de main d'oeuvre.—J'ai l'honneur de vous saluer,

" Le Comte Chaptal."

the intelligent person from whom we have received the more particular details of the present state of the French manufacture, observes, " Ces colloses, relativement aux petites filatures à bras, menacent d'ecraser les anciens systêmes. Le tems nous fera connoitre, s'il est possible de reunir en France, tous les elemens qui peuvent faire reussir les grandes fabriques; savoir les capitaux, les chefs economes et experimentés, les ouvriers habiles, soigneux, et appliqués, et la confiance dans l'avenir."

The only articles of cotton manufacture in which the French are at present on a footing with us, are their dyed goods, and their sewed muslins. The colours of the former are bright and durable, and the work put upon their embroidered muslins is designed with taste, and well executed.

It appears from official reports, that the quantity of cotton wool used in the French manufacture was, in the

Year 1798,	-	18,000,000 *lbs.*
1799,	-	10,290,000
1800,	-	6,726,000
1801,	-	11,008,000
1802,	-	15,120,000
1803,	-	15,780,000
1804,	-	17,200,000
1805,	-	18,412,000
1806,	-	21,734,000

The cotton imported in the year 1806 was manufactured into the following articles: About 1,000,000 lbs. into velvets; about 925,000 lbs. into nankeens, nankinets, crapes, and other small stuffs; about 1,155,000 into dimities; about 14,880,000 into fustians, calicoes, coverlets, simoises, muslins, &c. &c.

In twenty-two of the departments in France, in which this manufacture was carried on, there were at this time (1806) 7450 spinning mules, containing 800,724 spindles, and employing 28,460 persons; and there were in these departments 28,634 looms employed in weaving cotton fabrics, giving occupation to 31,107 persons. The number of machines and of people engaged in this manufacture in the other parts of the country are not stated.

In the same year, France imported (contraband) from England 2,000,000 of pieces of nankeen, 1,000,000 of pieces of cotton cloth for printing, and about 300,000 pieces of other descriptions of cotton goods, such as muslins, cambrics, dimities, &c. valued at three millions Sterling.

The cotton manufacture is carried on in France at present (1817) in the following districts:

At Paris they have a good deal of spinning, and they manufacture the best calicoes and the finest cotton hosiery produced in France. The manufacturers of Paris have also a number of people employed in spinning and weaving at Versailles, Essennes, Melun, Senlis, Royaumont, Liancourt, Chantilly, Gisors, Carlepont, &c.

The cotton manufacture is established on a more extensive scale in Rouen than in any other town in France; and it is not confined to the city, for the whole of Normandy is covered with cotton weavers, who carry on the business in their own houses, and send the goods they make to the hall at Rouen for sale. The manufacturers of Rouen have also numbers of workmen employed in the neighbourhood of St Quintin and Cambray, where their finest cloths are woven. The articles produced in Rouen, and in these dependent districts, are calicoes, coarse and fine, made to a great amount; velvets, also, in great quantity; coloured cotton goods of all descriptions; which last, from their superior knowledge in the art of dyeing, they execute well.

At Amiens, and in the neighbourhood, there is a great deal of spinning done, partly for hosiery, but chiefly for velvets, of which a large quantity is made in this district. The cotton manufacture has, in a great measure, supplanted the woollen manufacture formerly carried on here.

At Troyes, they manufacture dimities, fustians, swanskins, and different strong stuffs for furnitures and linings. There is also a considerable manufacture here of low priced hosiery.

At St Quintin, although the spinning is considerable, it does not supply above a fifth of the yarn used in the surrounding district, in which there are, it is said, 12,000 cotton weavers. These are employed upon different qualities of calicoes, upon cambrics for printing, upon dimities, and upon fancy goods, both white and coloured. There is no weaving done in the town; and in the linen manufacture formerly carried on here, 15,000 weavers were employed in making linens, thread, gauzes, and cambrics. These are now reduced to about 2000.

At Tarrare they make the finest book-muslins, but the yarn they use is all smuggled from England.

In the ci-devant province of Beaujolois, in which, till lately, no manufacture was carried on, they produce calicoes, low priced dimities, and stuffs for linings.

At Nismes, the people formerly were wholly employed upon articles of silk, but they now manufacture very fine cotton stockings, and fancy goods of different descriptions, woven with silk warp and cotton weft.

At Lyons, they have begun to make fancy articles in cotton, of superior taste and beauty as they boast, to any thing of the kind ever exhibited before; but the price of the goods they admit is very high.

The manufacture of Montpelier is now entirely confined to what are called Madras handkerchiefs, made in imitation of those of India.

The manufacture carried on in Cholet, Laval, and the surrounding country, was formerly wholly of linen. They now make calicoes, coloured cotton handkerchiefs in great quantities, and coloured handkerchiefs of cotton and linen. They have no spinning in this district.

The calico printers of Alsace, only a few years ago, drew their whole supplies of cloth from Paris, Rouen, and St Quintin. But, having been enabled to establish spinning works, with the assistance of a few Swiss emigrant workmen, who instructed the Alsacians; they introduced into their country the cotton manufacture, and are now in a situation to supply not only the goods required for their own printing, but have a surplus to dispose of for the consumption of others.

Cotton Manufacture.

Lille, Tourcoing, and Roubaix, with the surrounding country, form a spinning and manufacturing district. Lille and Tourcoing spin not only for their own consumption, but are able to furnish a great deal of yarn for the weaving carried on in the neighbourhood. The yarn produced in Roubaix, on the contrary, does not suffice for its own demands. The goods manufactured in this district are printanieres, thicksets, crapes, and nankinets. Formerly its weavers were employed on woollen stuffs, but this branch is now entirely given up.

At Cambray the weaving is considerable, but it is almost wholly carried on for the manufacturers of St Quintin and Rouen.

At present the cotton manufacture of France works up about thirty millions of pounds of cotton annually; and the value of this, when manufactured, is estimated at about ten millions sterling, nearly four-fifths of which they reckon to be workmanship.

Cotton Manufacture of Switzerland.

The people of free countries betake themselves more early to the pursuits of industry, than those who live under despotic governments; from the feeling, perhaps, that what their labour produces will be secured to them for their enjoyment. The Swiss boast that they manufactured muslins a hundred and fifty years ago. But if this were the case, these goods had certainly not been fitted to compete with the India muslins, with which the markets of Europe continued to be supplied, until the invention of the mule-jenny enabled the British muslins to rival them.

The cotton manufacture of Switzerland, whatever may have been the date of its commencement, had not at an early period been of much amount. It was even many years after Sir Richard Arkwright's improvements, before it began to make any considerable advance. It was not until the year 1798, that the Swiss had any spinning by machinery, at which time their first mill was erected at St Gall. Before that period all their yarn was spun upon the one thread wheel; and even still, about a tenth part of what they produce is spun in this manner.

After the introduction of machinery, however, the manufacture made rapid advances, and spinning works were erected in all the manufacturing cantons of the republic. In these they now spin water-twist up to No. 40, and mule yarn up to No. 80; but they import from this country all the higher numbers required in their manufacture.

A considerable proportion of their machinery is worked in the same manner as a part of the spinning machinery of France; a description of which we have given in our account of the cotton manufacture of that country; that is, in small systems; and, in Switzerland, these little establishments are scattered over the country.

In the manufacture of the goods, the weaver in general provides himself with the yarn, and sells the cloth, when woven, at the nearest weekly market, or exchanges it for a new supply of yarn. But there are also manufacturing capitalists, who employ a number of weavers, furnishing them with materials for the cloth, and paying them wages; only a small part of the manufacture, however, is carried on in this way.

Cotton Manufacture.

Although the manner in which the Swiss conduct this business, is not so well calculated to produce quantity, or to bring the article cheap to market, as the more perfect mode which we pursue; it leaves to the mechanic employed, a higher moral rank and character, and a greater possibility of worldly enjoyment, than belong to the working people of our more systematized establishments. Under the one, the workman appears to exercise independent labour, and his employment seems to be subservient to his own use and benefit. In the other we see him only as an accessory to some piece of machinery for supplying the elements of commerce; and, losing sight of the object of man's labour, the extension of his comforts and enjoyments, we are at last led to consider a nation as a great manufacturing concern, and increase of production as what is to be desired, at whatever expence of individual privation it may be obtained.

The quantity of cotton yarn used in the Swiss manufacture, when trade is in its ordinary state, is about 130,000 lbs. weekly. Of this quantity more than a half is imported; and of the remainder, nine-tenths are spun by machinery, and a tenth by the hand. Besides the machinery for spinning water twist, it is computed that there are in Switzerland 1200 mule jennies, averaging 216 spindles each. Spinning works are established at Winterthur, and in its neighbourhood; in the town and canton of Zuric; in the cantons of St Gall and Appenzell; of Argovia; of Thurgovia; of Geneva; and at St Blaze near Basil.

The goods manufactured are nearly of the same description as those made in Britain. The canton of Appenzell produces fine plain muslins, and the finest embroideries. The canton of St Gall, muslins, coloured pocket-handkerchiefs, cottonets, and the finest cotton cloths. The canton of Zuric on both the banks of the lake, produces about a thousand pieces of calicoes weekly. The cantons of Thurgovia and Argovia produce mostly coloured goods; and in these, and in the cantons of Zuric and Glaris, the printing of cotton cloths is carried on to a very considerable extent.

The wages at the present time, when, from the depressed state of trade, the price of labour every where over Europe is reduced to the lowest rate are, for a spinner, 18d. to 20d. a-day; a reeler 10d to 12d.; a weaver of calicoes 10d. to 12d. But the weavers of the finer articles, even at this time, can earn as much as 2s. 6d. or 3s. 4d. a-day, according to the fineness and necessary nicety of execution of the work in which they are employed.

Cotton Manufacture of Austria.

The cotton manufacture is prosecuted to a considerable extent in different parts of Germany. In Austria it is carried on principally around Vienna, in the neighbourhood of which city there are a number of large spinning works, all of which are moved by water. The business of spinning and that of manufacturing are kept quite separate. The weaving is done in Vienna and the surrounding country; and it is supposed that there are about 10,000 weavers em-

ployed. There is also a good deal of cotton woven in the mountainous part of Bohemia; but there is no cotton spun there; the Bohemians using principally English yarns. To facilitate the contraband introduction of these, by giving them the appearance of home production, spinning works have been established at Reichenberg, and at a few other places upon the Bohemian frontier. These yarns are woven into nankeens. The cotton goods manufactured in the Austrian dominions are of a stout fabric, and well executed; but they are dear when compared with English goods of a similar description. To give encouragement to the manufacture, the importation of foreign cotton yarn, of numbers below No. 50, and of foreign cotton cloths, is prohibited. Cotton yarn, of numbers above No. 50, is admitted on paying a considerable duty. *

Austria, in her present political state, cannot, we apprehend, be made a great manufacturing country. Commerce does not spring vigorously under the uncertainty which belongs to despotic rule; and if successful, the diffusion of wealth, which is its consequence, produces a spirit incompatible with the exercise of arbitrary power. Supposing, therefore, the manufactures of Austria, by factitious encouragement, brought to supply a part of her own consumption, she cannot continue to advance in these pursuits, without involving a change of her political circumstances.

Cotton Manufacture of Saxony.

In Saxony, the cotton manufacture, although, perhaps, not of greater amount than in Austria, is more generally diffused over the country, and exists under circumstances which promise a greater probability of future success. The habits and moral condition of the Saxon people are favourable to the successful prosecution of manufactures. They are sober, industrious, well educated, and frugal; and, added to these advantages, the administration of their government is liberal, and does not capriciously interfere with private pursuits. They have been long trained to manufacturing habits, having very early had an extensive linen business; and in introducing the cotton manufacture, nothing more was necessary than to transfer to the one, a part of the industry which had been employed in the other.

In 1799, after many unsuccessful attempts, Messrs Barnard and Brothers, with the aid of an English mechanic, erected, at Chemnitz, the first work which was established for spinning cotton in Saxony.

Their example was quickly followed by others; but from the imperfect knowledge which the Saxons then possessed of the mode of erecting these works, and from the reduction in the profits of spinning, which took place in consequence of the increased competition upon the Continent and from England, the undertaking proved unsuccessful. Those who engaged in it became loaded with large stocks of unsaleable yarn, which they were not able to get quit of until the blockade of the Elbe in 1804, and the subsequent occupation of Hanover by the French, excluded, for a time, the competition of England.

The Berlin decree in 1806, and the enforcement of Bonaparte's continental system, gave great vigour to the spinning trade in Germany. By the year 1808, the German spinners had more than indemnified themselves for the loss they had before sustained; and they continued to prosper, and to extend their business, till the success of the Allies, in the year 1813, put an end to the French yoke, and opened the country to the competition of foreigners.

Their machinery, however, had been greatly improved during this period, and the price of labour in Saxony being uniformly low, the Saxon spinners allege they would be able to compete successfully with the English, but for their greater capital, and the advantage which their geographical situation gives them in the purchase of the raw material.

They spin in Saxony mule yarn of a low quality, from Smyrna cotton, of numbers from No. 16 to No. 40, which they weave into thicksets, cotton velvets, and coloured pocket-handkerchiefs.

They spin likewise a second quality of mule yarn, of numbers from No. 36 to No. 54, from bowed or New Orleans cotton, mixed with Pernambuca or Smyrna cotton, according as they wish the quality to be better or worse. This yarn, which they work into cloths for garments, is unequal in the thread, but is preferred by the Saxon weavers to the English second quality of mule yarn, the cloth produced from it having, they think, more body.

They import, however, a considerable quantity of the second quality of yarn from England. There is very little mule yarn of the first quality spun in Saxony, and none of either quality finer than No. 56.

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* Since this article was written, Dr Bright's *Travels in Austria and Hungary* have been published; and contain some notices respecting the state of the cotton manufacture of Austria. He mentions that this manufacture is carried on to a considerable extent at Prague and Kuttenberg in Bohemia; and at Lettowitz in Moravia, and Gratz in Styria. He describes some of the establishments belonging to it, in the neighbourhood of Vienna, as upon a most extensive scale; that at Kettenhof giving employment to 14,000 people; and that at Ebreschsdorf, as still greater, giving employment to 20,000 people, spread through Bohemia and Moravia. Their large works, he says, have hitherto all been moved by water; but they have coal at Schauerleiten and Klingenfurt, in this district, and there is therefore a probability that the steam engine will soon be introduced.

He mentions the whole people employed in the cotton manufacture of Austria, as stated to amount to 360,000. But this number, we think, must be greatly exaggerated; although the spinners of cotton by the hand, of which, he says, there are still a great many in Austria, are comprehended in it.

The hand-spun yarn they produce is of the grist of No. 16. Their mule yarns are from No. 24 to No. 80.

Cotton Manufacture.

All the finer yarns, and nearly the whole of the water-twist required in their manufacture, are imported from England. The yarn, whether spun at home or imported, is sold to the weavers, who are scattered over the country, and, by them, is converted into cloth, which they dispose of at the weekly market of the nearest town.

Cotton Manufacture of Prussia.

The cotton manufacture is carried on also in Prussia, and there is in the temperament and habits of that people, what leads us to expect that they may become a manufacturing nation. At present, however, like the Austrians, Saxons, and other nations upon the Continent who have attempted to carry on this manufacture, they are far behind in the knowledge of the means of economising labour, and in that readiness and precision of execution which the workmen of this country possess. But these they will soon acquire, if the business continues to be prosecuted by them. In the meantime, they have labour at a cheaper price than that at which we can generally command it; and in manufacturing for markets which lie near to themselves, they can, better than we at a distance, adapt the fashion and fabric of the goods to the changes of taste, and accommodate the supply to the exact measure of the demand.

Cotton Manufacture of Russia.

In Russia they have begun to manufacture cotton upon a small scale. At St Petersburg there is one spinning work, carried on by the Emperor, of course at a great expence. They also spin some cotton yarn upon the distaff. In addition to these supplies, they import annually from this country about 3,000,000 libs. of yarn, of numbers from No. 18 to No. 46. The weaving is carried on in Moscow and its neighbourhood; and, latterly, along that line of country stretching towards the Caspian Sea, particularly about Sarepta; where a colony of Moravians has for some time been established. The goods produced are used chiefly for the garments of the peasantry.

Before concluding this article, it will be necessary to take some notice of the premature attempts which have been made to establish the cotton manufacture in the United States of America.

Cotton Manufacture of America.

The American Government has evinced great anxiety for the accomplishment of this object, without considering that manufactures are valuable to a country, only in as far as by their means the people can be supplied with the article cheaper than they are able to procure it elsewhere. When a manufacture requires the support of bounties, or of laws prohibiting the importation of similar articles, it is a consumption of the national wealth to encourage the prosecution of a branch of industry incapable of maintaining itself. There is no greater error in policy than this; and yet we see it every day committed, by young nations *forcing* manufactures, before the circumstances of the country admit of such undertakings; and by old nations persisting in the manufacture of articles which, from natural disadvantages, they cannot produce at so low a price as that at which they might purchase them from others.

The favourite system of a country supplying every thing within itself, is alike adverse to individual advantage, and to the increase of national riches. A division of employments among nations, founded upon existing, local, or accidental circumstances, is as much in unison with the sound principles of political science, and as much calculated to promote the general benefit, as is the division of labour and of employments among individuals. It is not by a nation manufacturing every thing it consumes that it is to be made rich, but by its people being profitably employed; and this can only be accomplished by the industry which every individual practises, being what he can, with advantage to himself, exchange with the industry practised by others. Under this order of things, the production of the whole will be the greatest, and every one be best paid for what he produces. If these principles be just, it must be a misapplication of American capital and industry to withdraw them from their present employment, in extending the cultivation of the soil, and in circulating its products —undertakings which the people find profitable,— to force them into manufacturing concerns supported by monopolies and bounties.

Before America can be in a state to carry on manufactures in competition with those of Europe, her vast tracks of unoccupied land, into which the growing population of her older settlements is regularly flowing, must be stocked. Until this is the case, her supply of labourers will be kept below the demand, and the wages of labour above those paid in the better peopled countries of Europe. Besides the effect which this state of the supply of labour has in increasing the cost of the article, it is adverse to the proper and advantageous execution of the work. The workmen are too independent, and in consequence too unsettled, to submit to that discipline and course of training, from which alone excellence of quality, and a steady production of quantity, are to be obtained.

In the account we are to give of the American cotton manufacture, we shall chiefly refer to the public documents; in which its growth is studiously detailed, and the difficulties it has had to struggle with, anxiously dwelt upon.

Before the year 1791, any manufacture they had was of domestic production and for family use. But in that year a cotton mill was erected in the State of Rhode Island, as appears from a report from the Secretary to the American Treasury, drawn up in the year 1810. This report farther informs us, "That another mill was erected in the same State in the year 1795; and two more in the State of Massachusetts in the year 1803 and 1804: That during the three succeeding years, ten more were erected in Rhode Island, and one in Connecticut, making together fifteen mills, working about 8000 spindles, and producing about 300,000 lbs. of yarn a-year.

"That returns have been received of eighty-seven mills which were erected at the end of the year 1809; sixty-two of which (forty-eight water and fourteen horse mills) were in operation, and worked at that time 31,000 spindles: That the other twenty-five mills will be all in operation in the course of this year, and together with the former ones (all of which

are increasing their machinery) will, by the estimate received, work more than 80,000 spindles at the commencement of the year 1811.

"That the capital required to carry on the manufacture on the best terms, is estimated at the rate of a hundred dollars *per* spindle; but it is believed that not more than at the rate of sixty dollars is generally employed. Each spindle produces annually about 36 lbs. of yarn from 45 lbs. of cotton, and the value of the yarn may be averaged as worth one dollar twelve and a half cents *per* lb. Eight hundred spindles employ forty persons, viz. five men, and thirty-five women and children.

"That the increase of carding and spinning cotton by machinery in establishments for that purpose, exclusively of that done in private families, has been fourfold during the last two years, and tenfold in three years. Thirty-six of these mills, working 20,406 spindles, are situated within thirty miles of Providence. The remainder are scattered all over the country."

Morse, in the last edition of his *Geography*, gives the same account of the state of the cotton manufacture of America, at the end of the year 1810, as this report; and adds, that the cloths manufactured were bed-ticking, stripes and checks, ginghams, cloths for shirts and sheetings, counterpanes, webbing and coach laces, diapers, jeans, vesting, cotton kerseymeres, fustians, cords, and velvets. In the enumeration given of the manufactures carried on in the separate states of the Union, the cotton manufacture seems to be confined to the States of Rhode Island, Massachusets, New Jersey, and New York.

The spinning works mentioned in the preceding report, appear all to have been upon a very small scale, and the number of hands employed, to the quantity of machinery specified, much greater than is found necessary in this country, where labour is so much cheaper. The capital too, said to be used for carrying on the business, seems unnecessarily large.

The farther progress and recent state of this manufacture, we learn from a report of a Committee of the House of Representatives, presented in the spring session of 1816. This report states,

"That the quantity of cotton manufactured in the year 1815 was 90,000 bales," a quantity nearly equal to that used in the cotton manufacture of France. "That the quantity used in 1810 was 10,000 bales; in 1805, 1000 bales; and in 1800, 500 bales." This statement, the Committee say, "they have no reason to doubt; nor have they any to question the truth of the following succinct statement of the capital which is employed, of the labour which it commands, and of the products of that labour."

Capital employed, - -	(doll.)	40,000,000
Males employed from the age of 17 and upwards, - - - -		10,000
Women and female children, -		66,000
Boys under 17 years of age, -		24,000
Cotton wool manufactured, 90,000 bales, - - -	(libs.)	27,000,000
Cotton cloth of various kinds manufactured, - -	(yards)	81,000,000
Cost, - - -	(doll.)	24,000,000

The report proceeds to say, "That the manufacturers of cotton, in making application to the national government for encouragement, have been induced to do so for many reasons. They know that their establishments are new and in their infancy; and that they have to encounter a competition with foreign establishments that have arrived at maturity, that are supported by a large capital, and that have from the government every protection that can be required."

"The committee, from the views which they have taken, consider the situation of the manufacturing establishments to be perilous. Some have decreased, and others have suspended business. A liberal encouragement will put them again into operation with increased powers; but should it be withheld, they will be prostrated. A capital of near thirty millions of dollars will become inactive, the greater part of which will be a dead loss to the manufacturers. The Committee, from all the consideration they have given to this subject, are deeply impressed with a conviction, that the manufacturing establishments of cotton wool, are of real utility to the agricultural interest, and that they contribute much to the prosperity of the Union. Under the influence of this conviction, the Committee beg leave to tender respectfully, with this Report, the following resolution:"

"That from and after the 30th day of June next, in lieu of the duties now authorized by law, there be laid, levied, and collected, on cotton goods imported into the United States and territories thereof, from any foreign country whatever, *per centum ad valorem*, being not less than cents *per* square yard."

At this time the duty upon cotton goods imported into the United States was 15 *per cent.* But before charging it, 10 *per cent.* was added to the invoice, and the duty levied upon the gross sum,—raising it by this means to $16\frac{1}{2}$ *per cent.* Upon the recommendation of the Committee, in consequence of the above report, 10 *per cent.* more was imposed, and the whole being charged upon L. 110 for every L. 100 of neat value, brought it up to $27\frac{1}{2}$ *per cent.* But, besides this, all cotton goods below $13\frac{1}{2}$d. *per* yard, were ordered to be rated at $13\frac{1}{2}$d., and the difference added to the amount of the invoice before calculating the duty. This regulation was meant as a particular encouragement to the home manufacture of the coarser articles.

The great extent of the American cotton manufacture, stated in the preceding report, is more like what the sanguine views of the parties had contemplated, than what had been actually achieved. Indeed, it would have been impossible, even in a country with an extensive population, and established manufacturing habits, to have reared in the time a manufacture of the magnitude they mention. But whatever prosperity it had attained, was put an end to by the restoration of peace with England; and this, notwithstanding of the heavy tax levied on foreign cotton goods. American capital and industry

immediately returned to their former channels, in which they will probably continue to seek their employment, until the settling of new lands becomes less advantageous, and a more abundant population gives a greater command of labour.

That the failure of these attempts. however, was not occasioned by any defect in the plan or general conduct of the establishment, we know from a gentleman who visited the principal cotton works in America in the year 1816. He found the machinery in many of them of excellent construction, and those who had the charge of them, men who had been bred in this country, and who were possessed both of skill and judgment. But the circumstances in the state of America, which we have mentioned, were so adverse to the nature of the undertaking, as to render success, in the opinion of these persons, impossible.

We have now completed our account of the cotton manufacture; a branch of industry which, next to the cultivation of the soil, furnishes, we believe, a more extensive employment to labour and capital than belongs to any of the other occupations of man. Even in the brief statistical details to which we have been necessarily confined, the political economist will, perhaps, be able to discover circumstances, which have retarded or facilitated the progress of industry and improvement. In the history of this manufacture, during the short period that it has existed in Britain, readers of every description will meet with matter to engage their attention; while the display of human ingenuity and talent, in the inventions and discoveries to which it has given rise, and the influence of these upon the human character, are calculated not only to excite general interest, but to furnish valuable and instructive materials for the speculations of the philosopher. (T. T.)

COULOMB (CHARLES AUGUSTIN), a profound and ingenious theoretical mechanic and natural philosopher, descended from a distinguished family of Montpelier, was born at Angoulême, the 14th of June 1736. He felt, at an early period of his life, a strong preference for mathematical studies, and would gladly have devoted his whole attention to the pursuit of science; but he found it more convenient to enter the military profession as an engineer. This department, however, afforded him ample scope for the exercise of his powers of observation and calculation: and after having been ordered on service to America, and remaining abroad nine years, with some injury to his health, he presented to the Academy of Sciences, in 1773, a memoir on cohesion, and on the resistance of various works of masonry, which, for the accuracy and originality of the views that it exhibits, for the clearness and neatness of the demonstrations, and for the practical utility of the results, is fully equal to any of his later productions, and shows a mind still in the vigour of youth, and yet matured by the approach of middle age. The Academy paid him the compliment of making him one of its correspondents, and in 1779 he had the satisfaction of sharing, with the laborious Van Swinden, the prize proposed for improvements in the construction of compasses. He resided for some time at Rochfort, where he had abundant opportunity of prosecuting, in the naval arsenal, his experimental researches on friction, which obtained him in 1781 the double prize for the theory of the effects of simple machines: in the same year he had the good fortune to be stationed permanently at Paris, and becoming a member of the Academy, devoted himself entirely to the investigation of the laws of electricity and magnetism, and of the force of frictions and resistances of various kinds. He is generally supposed to have been the first that proved, by direct experiments, the law of the decrease of electrical and magnetic forces in the proportion of the squares of the distances: but it must not be forgotten that the late Lord Stanhope had published an experiment, five years before the date of Mr Coulomb's researches, which sufficiently established this law with respect to electricity; although the extension of the same law to the operation of magnetism appears to belong exclusively to Mr Coulomb. He continued to occupy himself in these researches till the time of the revolution, when he was expelled from Paris by the decree that banished all the nobility; having before given up the appointment of Intendant general of fountains, and having otherwise very materially suffered in his property. He retired with his friend Borda to a small estate which he possessed at Blois; and during his residence there, made some observations on vegetable physiology, which he afterwards presented to the Institute.

He was recalled to Paris in order to take a part in the new determination of weights and measures, which had been decreed by the revolutionary government. He returned, soon after, into the country, wishing to devote himself to the care of his family, and of the remains of his little fortune. But upon the establishment of the National Institute, he again became an inhabitant of the metropolis. He had, however, occasion to undertake a tour of considerable extent, in discharging the duty of an inspector of public instruction; and he was remarked, in his examinations of the young students, for the singular good nature and paternal tenderness of his manners. He still continued his application to his favourite pursuits, and in particular to the investigation of the magnitude of forces of various kinds, by means of the principles of torsion. And his last study was an inquiry respecting the universal diffusion of the magnetic power through nature, which he at first supposed to be almost unlimited; although he afterwards found reason to conclude, that its general cause was the presence of a minute quantity of iron. A short summary of his numerous and elaborate memoirs will best illustrate the extent and accuracy of his researches.

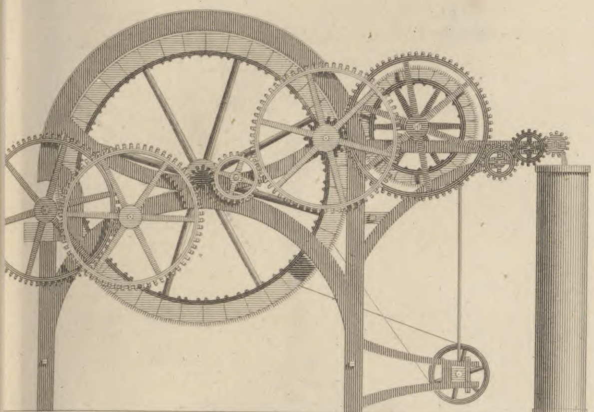
1. *Statical Problems relating to Architecture. Mém. Sav. Etr.* VII. 1773. p. 343. The fluxional modes of ascertaining maxima and minima are applied, in this admirable memoir, to the determina-

COTTON MANUFACTURE.

CARDING.

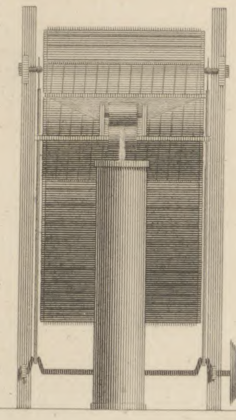
Side Elevation of Cards.

Fig. 1.



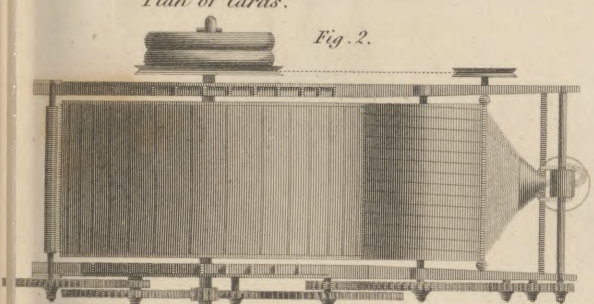
Front Elevation of Cards.

Fig. 3.



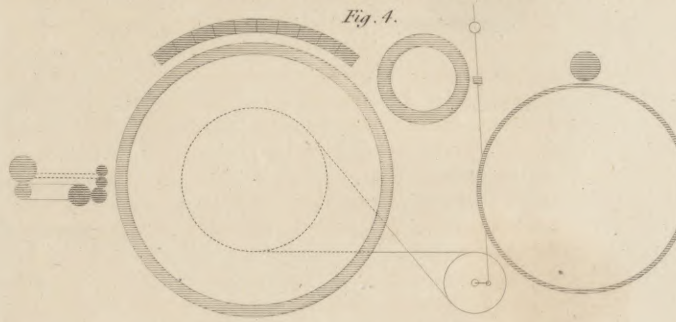
Plan of Cards.

Fig. 2.



Vertical Section of Cards.

Fig. 4.



DRAWING AND ROVING.

Fig. 5.

End Elevation of Drawing frame.

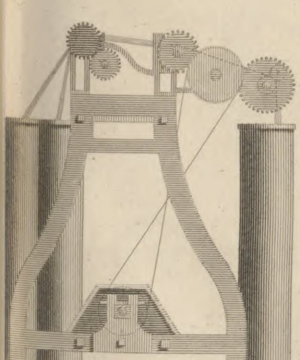


Fig. 7.

End Elevation of Roving frame.

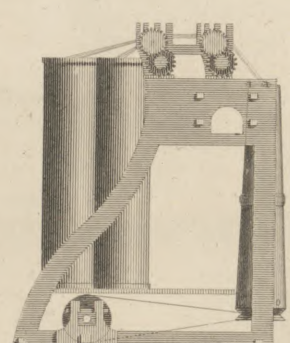
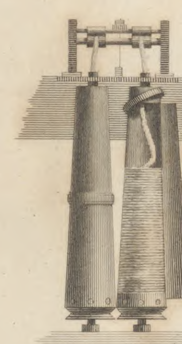


Fig. 9.

Front Elevation of Roving or Can frame.



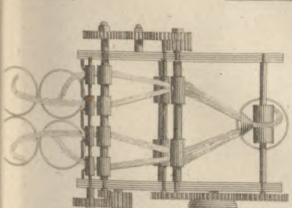
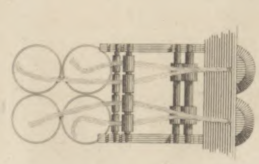


Fig. 6.

Plan of Drawing frame.

Fig. 8.



Plan of Roving frame.

Edm.d Turrell, sc.

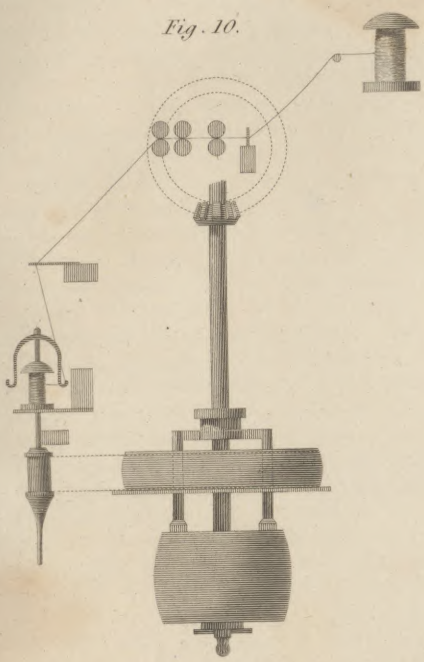
Published by A. Constable & Co. Edin.r 1818.

COTTON MANUFACTURE.

TWIST SPINNING.

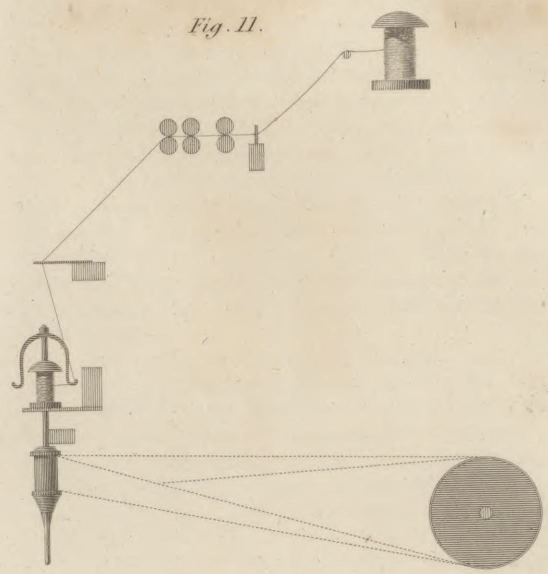
Sir R. Arkwright's, Spinning Frame.

Fig. 10.



The Throstle.

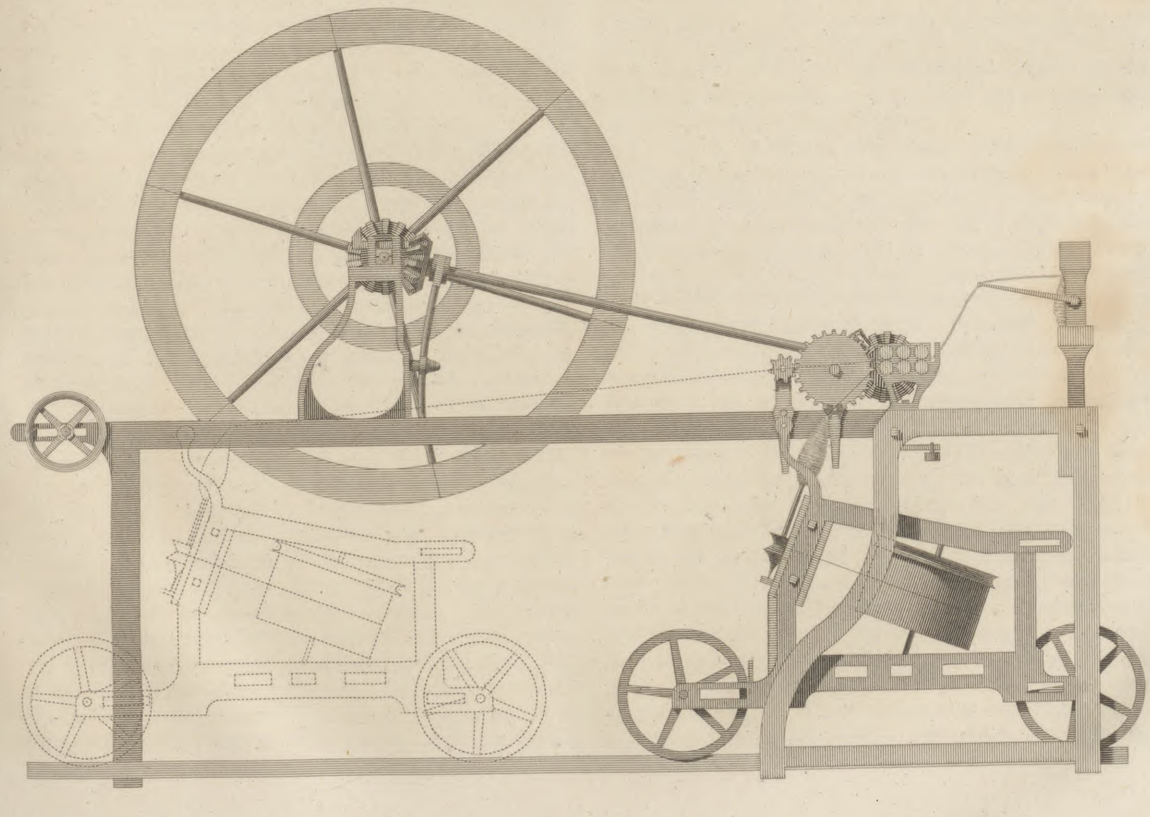
Fig. 11.



MULE SPINNING.

The Mule Jenny.

Fig. 12.



Edmd. Turrell Sc.

Published by A. Constable & Co. Edinr. 1818.

tion of the strength of blocks of stone, and of pillars of masonry, and to that of the resistance of semi-fluids, and the thrust of earth. The author's manner of considering the subject was at that time new; it has been still further extended by some late researches in this country (*Hutton's Mathematical Dictionary, Art. Pressure*); and many of the calculations, contained in the articles BRIDGE and CARPENTRY of this *Supplement*, are principally founded on the same basis. Mr Coulomb very properly objects to Musschenbroek's mode of representing columns as exerting their passive strength like bars resisting flexure; and it is surprising that Mr Lagrange did not profit by his remarks, in abridging his laborious investigations of their elastic force. Mr Coulomb appreciates the friction of soft materials by the angle at which they will stand unsupported: an angle which has been termed in this country the angle of repose, by an author who perhaps imagined there was more novelty in the idea, than he would have done, if this memoir had been fresh in his mind. For the thickness of the walls of an embankment, one-seventh of the height is recommended as a good proportion in common cases, with an increase of one-sixth towards the bottom: But the calculation is left in some measure incomplete, although it may be sufficiently accurate for the cases which most commonly occur in practice. In the last place, the proper direction of the joints of flat arches is determined; and the point of easiest fracture of arches in general is investigated, by an approximatory method, applied successively to each joint.

2. *On the improvement of the construction of the Compass. Mém. Sav. Etr.* IX. p. 165. This memoir contains a laborious and accurate investigation both of the operation of the force of magnetism, and of the resistances exhibited to the motion of a needle by friction or by other causes. The author lays down, as a fundamental principle, the equality of the accelerative force acting on a given needle, in all positions, when referred to the direction of the meridian; so that the properties of its vibrations become precisely similar to those of a pendulum actuated by the force of gravity. From the existence of an attractive and a repulsive force at the same time in each particle of the body, with respect to the opposite magnetical poles of the earth, he concludes the total impossibility of explaining the effects by means of any ethereal currents or vortices, which had been admitted by some of the best mathematicians of the century, then still surviving. He examines the comparative force of needles of different dimensions, and proves the extreme delicacy of the suspension afforded by a long fibre, whether of hair or silk; and he describes a compass in which the reading is performed by means of a microscope fixed to a graduated arm, serving as a vernier. In order to find the true direction of the magnetic action of a needle, he turns it upside down, and takes the mean of the observations. He ascertains the magnitude of the friction of steel on glass, by measuring the angle of repose; and he finds that it is equal to $\frac{2}{11}$ of the pressure He then proceeds to calculate the friction of a pivot, supposing it to be compressed most at the centre, but concludes, from a hasty experiment, that the magnitude of the surface is not much changed by a change of pressure. He infers, however, that a light needle has an advantage over a heavy one. A perforation in the middle of a needle appears to interfere but little with its magnetic force. He proposes to ascertain the position of the dipping needle, by measuring the frequency of the horizontal vibrations, and the force required to keep it level; and he concludes his memoir with an account of the diurnal variations of the needle, and a conjecture respecting the operation of the sun and his atmosphere, which he compares to a large aurora borealis; referring the secular change of the variation to the slow motion of the sun's apogee.

3. *Recherches sur les moyens d'exécuter sans l'eau toutes sortes de travaux hydrauliques*. 8. Par. 1779. Rozier XIV. P. 393. *Addition*. Rozier XVII. P. 301. Ed. 2. 8. Par. 1797. The Academy of Rouen had proposed a prize for an essay on the best mode of lowering a rock in the Seine, at Quillebeuf, which was about a foot below low water mark: this essay was originally written for the prize, but it was published without waiting for the competition, at the request of some engineers, who wished to have it made known without loss of time. The method recommended consists in employing a floating air chest in the manner of a diving bell, forcing out the water from its lower part by means of bellows, after shutting up the workmen in the upper part. In the additional paper, printed in the *Journal de Physique*, a stronger pneumatic apparatus is described, somewhat resembling the air vessel of a fire engine, which discharges its air into the chest, and is then filled again by letting out the water: it is also proposed to employ mercury, in a similar manner, in the construction of an air pump. The proposed apparatus does not appear to have been tried; but there can be no doubt that it might often be of advantage, when the inequalities of the rock, or any other causes, prevented the construction of a cofferdam.

4. *Theory of Simple Machines, comprehending the effects of friction and of the stiffness of ropes. Mém. Sav. Etr.* X. P. 161. This essay gained the double prize proposed by the Academy for 1781; the difficulty of performing experiments on a large scale having probably prevented the presentation of any memoir sufficiently comprehensive the preceding year, when the subject was first proposed. The author's principal merit consists in the determination of the different magnitude of the initial adhesion, according to the time that the substances had continued in contact with each other, and had been pressed together, and of the effect of the magnitude of the surface of contact of particular substances, as well as of the causes of the occasional difference of friction, with different velocities, especially when the unctuous substances employed are rendered too soft by the heat, which is produced by the motion. He compared the effect of the mutual contact of a great variety of substances; and for the purpose of launching ships, he recommends the use of oak, sliding on elm, previously well rubbed with hard tallow; but in some other cases he found tallow, if not frequently renewed, rather injurious than serviceable. He observed, that the

Coulomb.

rigidity of ropes increased more rapidly than their diameter, but somewhat less rapidly than their strength; and that in order to overcome this rigidity, besides a constant force, an additional force was required, proportional to the weight employed. With every allowance for resistance of all kinds, he calculates, that a well constructed machine, for instance a simple capstan, raising a large weight, will produce an effect equivalent to nine-tenths of the force employed. But, in many of the simple machines in common use, for instance in ships' blocks of the ordinary construction, it appears, from the reports of other authors, that the loss frequently amounts to more than half of the power.

5. *Observations on the force of Windmills, and on the form of their sails. Mém. Ac. Par.* 1781. P. 65. The inclination of the sails, found to succeed best in practice, varied from 60^0 to 80^0 in their different parts. The force was estimated by the weight of the stampers, raised in the process of extracting rape oil, and it appeared that only about one seventh of the power of the wind was lost. On an average the wind was observed to blow eight hours a-day, with a velocity of fifteen English miles an hour; and the work of the mill was generally so arranged, that the velocity of the sails was in a certain proportion to that of the wind, experience having shown, that the effect thus obtained was the greatest possible. Mr Coulomb attempted to become a tenant of one of the mills for a few months, in order to make experiments on it with the greater convenience: but the proprietors suspected that he wished to discover some of their secrets, and refused to comply with his proposal.

6. *Theoretical and experimental researches on the force of Torsion. Mém. Ac. Par.* 1784. P. 229. The force of torsion is here very accurately and elegantly determined for substances of different diameters; and it may be inferred from Mr Coulomb's experiments, that the resistance of a steel wire, to a force tending to twist it, is always equal to that of a fixed axis, supposed to be $\frac{15}{100}$ as great in diameter, having the same wire coiled round it, or rather simply attached to a point of its circumference: for brass wire the proportion must be $\frac{9}{100}$; and according to Mr Cavendish's experiments, it must be $\frac{1}{10}$ for copper; not $\frac{1}{100}$, as has been stated by an accidental error, either of the printer's or of the calculator, in the article CARPENTRY of this Supplement, p. 622. The reaction of brass, notwithstanding its greater flexibility, is more perfect and durable than that of steel, and it is therefore preferred for the construction of balances for the measurement of minute forces by the effect of torsion, several varieties of which are here described: And as an instance of their utility, the author has ascertained, that the resistance of liquids depends almost entirely on two forces, the one varying as the velocity, the other as its square, the constant portion of the resistance being scarcely perceptible in any case. He proves, that tempering a bar or wire, of any metal, has no effect in the immediate force of its resistance at a given flexure, although it very materially modifies the extent of its action. Continued twisting of a soft wire seems to produce a very equable degree of hardness, which enables it to retain nine times as much magnetic power as in its original state: and on account of this increase of hardness only, a soft wire appears to exhibit a greater extent of elastic recoil when it is twisted round several times, than when only once or twice.

Coulomb.

7. *Description of a Compass. Mém. Ac. Par.* 1785. P. 560. The needle is suspended by a number of single threads of silk, made to adhere by dipping them in hot water, or by means of a little gum, each thread being capable of bearing a weight of about 50 grains. The needle is to be so suspended, that the thread may have no tendency to cause it to deviate from the magnetic meridian; and this is to be ascertained by substituting a copper wire in its place. Cassini was in the habit of employing a compass of this construction, for making accurate observations on the diurnal variation.

8. *Three Memoirs on Electricity and Magnetism. Mém. Ac. Par.* 1785. P. 569, 578, 612. The first memoir is devoted to the description of an electrical balance. founded on the force of torsion, and to the demonstration of the law, according to which small bodies similarly electrified repel each other, with a force decreasing as the squares of the distances increase. One of the instruments employed was so delicate, that each degree of the circle of torsion expressed a force of only one hundred thousandth of an English grain; another, suspended by a single fibre of silk four inches long, made a complete revolution with a force of one seventy thousandth of a grain, and turned to the extent of a right angle, when a stick of sealing wax, which had been rubbed, was presented to it at the distance of a yard. The second memoir relates to the laws of electric attraction, and of the magnetic forces, which are all found to vary in the same proportion as the electric repulsion. The direct experiments, on the attraction of balls contrarily electrified, presented some difficulties, and the vibration of a small needle, at different distances from an electrified body, was employed for a collateral experiment. The poles, in which the magnetic forces appear to be concentrated, are at some little distance from the respective ends of a magnetic bar, and not exactly at the extremities. In the third memoir, Mr Coulomb investigates the laws of the gradual loss of the electricity of an insulated body, which seems to be always proportional to the intensity of the charge, and independent both of the form and of the conducting power, except in the case of sharp points or edges: it appears also to vary nearly as the cube of the quantity of water contained in the air, though probably somewhat diminished by an increase of temperature. It is however remarkable, that changes of moisture, indicated by the hygrometer, are not discoverable in the conducting power, for a considerable time afterwards. The quantity of electricity carried off by the air being ascertained, that which is lost by the imperfection of the insulating support remained to be determined: and it was found, that a certain length of a fibre of silk, varying as the square of the intensity, produced complete insulation with respect to all weaker charges.

9. *Fourth Memoir on Electricity. Mém. Ac. Par.* 1786, P. 67. It is here shown that the capacity for

receiving electricity is totally independent of any chemical attraction of the body for the supposed fluid; since balls of copper and of pith, or plates of iron and of paper, when brought into contact with each other, divide the electricity in equal proportions. It is also experimentally proved, by boring cylindrical holes in a large piece of wood, and touching the bottom of the holes with a small circle of gilt paper, that the interior parts of an electrified body remain in a state of indifference.

10. *Fifth Memoir on Electricity. Mém. Ac. Par.* 1787, P. 421. When a large globe touches a smaller, the smaller receives a charge, which is stronger than that of the larger, but never twice as strong. It is proved by measuring the intensity of the electricity of a varnished wire or cylinder, that bodies are not surrounded by an electric atmosphere, but receive the charge within their substance; for the varnish, which is impermeable to the fluid, does not sensibly affect the capacity of the cylinder.

11. *Sixth Memoir on Electricity. Mém. Ac. Par.* 1788, P. 617. This interesting investigation relates to the distribution of electricity between a number of equal globes; in the different parts of a long cylinder; between a large globe and a number of small ones; and between a globe and a cylinder. In showing the agreement of the theory with experiments, Mr Coulomb's industry and ingenuity are very successfully exerted in order to overcome the difficulties of the approximatory calculation, although it might perhaps have been not much more laborious, and yet far more satisfactory, to have proceeded to a more correct and conclusive analysis. In a series of twenty-four globes, the charge of the first was to that of the second as three to two, and to that of the twelfth as seven to four; in a cylinder fifteen diameters long, the intensity at the end was to the intensity at the middle as twenty-three to ten. Of twenty-four small globes in contact with a larger, the last exhibited an intensity about four times as great as the first. The experiments on globes and cylinders combined are still more interesting, as affording an immediate application to the effects of conductors in carrying off electricity. At the remote end of a long cylinder equal in diameter to one twelfth of that of the globe, the intensity was nearly twenty times as great as that of the globe; and it increased almost in the same proportion as the diameter of the cylinder or wire was diminished; but a short wire received a much weaker charge. From the formulæ founded on these experiments, Mr Coulomb calculates, that a cloud, a thousand feet in diameter, will cause a wire a line in diameter, raised by a kite, to receive an electricity at the lower end more than sixty thousand times as great as its own. He also observes, that a point projecting but little from a large surface discharges electricity but slowly; a plane touching a globe received an electricity, equally intense with that of the globe, on both its surfaces. Mr Coulomb considers the hypothesis of the existence of two electric fluids as less objectionable than the theory of Franklin, Æpinus, and Cavendish, though he does not attempt to give any direct proof that he can decide the question; but he finds it difficult to believe, that matter can repel matter, and attract the electric fluid, with forces precisely equal, at the same time that matter is known to attract matter with a force of gravitation, varying according to the same law, but incomparably less active. It does not, however, appear that this difficulty is by any means a very important one, since we may avoid it altogether, by supposing that matter only repels matter, and that it attracts the electric fluid, with which matter is commonly saturated, with a force somewhat greater, so that the difference of these forces constitutes gravitation; which thus, like the newly discovered chemical attractions depending on electricity, may be reduced to a modification of the power of this wonderfully universal agent; an agent which appears almost to combine the subtility of spirit with the energetic qualities of matter. It must, however, be remembered, that we have no evidence of the separate existence of electricity, independently of matter; it does not pass, like light and heat, through the vacuum of the barometer; nor, in all probability, through the empty spaces interposed between the different parts of the solar system; although the accelerative force, depending on it, is not confined by these or by any other limits; and it will probably long remain a question, whether electricity may not rather be a modification of matter or motion in the bodies concerned, than a semimaterial substance pervading them; especially among those who even doubt of the materiality of light and heat as separate substances.

12. *Seventh Memoir, relating to Magnetism. Mém. Ac. Par.* 1789, P. 455. In order to check the irregular oscillations of needles very delicately suspended, Mr Coulomb finds it convenient to attach to them a horizontal plate, immersed in a vessel of water. The directive power of a needle of given thickness appears to be nearly proportional to its length, the quantity of magnetism accumulated near the ends being constant, except that it extends to the distance of about twenty-five diameters, and if the needle is too short to allow space for this accumulation, the directive power decreases as the square of the length. The directive forces of similar needles, composed of pieces of the same twisted wire, are nearly as their weights. Mr Coulomb observes the difficulty of accounting for the well known fact, that neither half of a needle, when it has been divided, appears to be attracted either northwards or southwards, and he thinks that whether we admit the existence of one magnetic fluid or of two, it will still be necessary to consider every magnet as made up of minute parts, each possessing a north and a south pole, of intensities varying according to their situation; and he remarks that the high charges of electricity, supported by very thin plates, afford an analogy favourable to the existence of this kind of partial charge of magnetism; he might also have added, after the happy combinations of Volta, that the electrochemical battery exhibits an arrangement almost identical with that which he attributes to a magnet. With respect to the forms of needles, the rhomboid appeared to have some advantage over the rectangle: the temper required to be neither very hard nor very soft, and it was found best to anneal the needles to

a dark red, or to employ plates of a spring temper, when they required to be larger. A number of needles combined into a mass lost more than half their strength, so that it is of advantage to attach several parallel needles, at a distance from each other, to the card of a compass. Mr Coulomb's mode of communicating magnetism is to lay the ends of the bar on those of two strong magnets, placed opposite to each other, and to draw two other magnets repeatedly along it, in an inclined position, from the middle to the respective ends, in opposite directions at the same time. His large battery consisted of a number of plates surrounding two pairs of pieces of soft iron, which formed the ends of each compound magnet, while the middle was left hollow: the whole weighed 30 or 40 pounds, and would lift 80 or 100, and it communicated to common needles as much magnetism as they were capable of retaining, when their ends were merely placed on it, without any farther operation.

13. *Examination of the friction of Pivots. Mém. Ac. Par.* 1790, P. 448. Mr Coulomb tacitly acknowledges, in this paper, a slight inaccuracy in his former experiments on the friction of pivots, the result of which seemed to indicate that the rotatory resistance of the friction was simply as the pressure, independently of any change of the magnitude of the minute surface of contact: he now finds that this is only true of smaller weights, when the pivot has already supported a larger, and its surface has probably been a little flattened: otherwise, the observation agrees more nearly with the theory; and perfectly so on the supposition of a conical point affording a resistance proportional to the displacement of the surface. The friction of steel on garnet is a little less than half as much as on steel; on agate, a little more than half; and on glass, four-fifths. Light needles, with a pivot tapering in an angle of about 20°, seem to be the most advantageous for common purposes; but if the needle is heavy, the point must be more obtuse. The conoidal caps, commonly used for suspending needles, had always an irregularity at the centre, which made the friction many times greater than that of a well finished surface, uniformly concave.

14. *Experiments on the Circulation of Sap. Mém. Inst. Sc.* II. P. 246. Mr Coulomb seems to have sufficiently ascertained that the sap appears to rise, in the poplar, near the centre of the tree, mixed with a considerably larger portion of air, which is extricated with a hissing noise, when the tree is cut or bored; it is not, however, certain that this air is in an elastic state while the vessels remain closed. The phenomena was first observed in April, and continued throughout the summer, being most distinct in the hottest sunshine.

15. *Observations on the daily Labour of Men. Mém. Inst. Sc.* II. P. 380. This memoir was read to the Academy of Sciences in 1775, but was not then published. Mr Coulomb's general conclusion is in favour of the employment of strength in ascending stairs; but he observes, that former authors have very frequently exaggerated the whole amount of a man's daily labour. In fact, the day's work, which he assigns to a man of ordinary strength, thus employed, is less than half of that which Desaguliers attributes to a labourer turning a winch: and Professor Robison has recorded, in this *Encyclopædia*, more than one instance of a much larger result of the labour of a man ascending an inclined plane, even besides the force lost in the machinery employed: so that we must suppose the labourers in France to be commonly less vigorous than in Great Britain; almost in the same proportion, as Mr Coulomb has observed the work of the same man in Martinique to be less than in France.

16. *Comparison of the Magnetic Powers of different Needles. Mém. Inst. Sc.* III. P. 176. A number of accurate experiments are here adduced in confirmation of the theoretical conclusion, that needles of a similar form, and composed of portions of the same wire, possess directive powers which are very nearly proportional to their weights.

17. *On the Cohesion of Fluids, and their Resistance to Slow Motions. Mém. Inst. Sc.* III. p. 246. The interesting experiments here related, demonstrate that the constant part of the resistance of fluids is insensible: that the portion varying simply as the velocity is more than seventeen times as great in oil as in water, while the portion, which varies as the square of the velocity, is nearly equal in both these fluids. The resistance did not increase with the depth of immersion; on the contrary, it was a little greater when the body was partly above the surface. It was observed, that very slow oscillations were somewhat accelerated even by the motion of a carriage passing along the street. Greasing the surface of the solid did not sensibly lessen the resistance to its motion, nor was it materially increased by sprinkling sand on the grease; so that the particles of the liquid seemed to slide rather on each other than on the solid. But it is probable that these differences would have been more perceptible in greater velocities; for it seems reasonable to expect, that the friction between a fluid and a solid should partake, in a slight degree, of the nature of the friction between two solids, so as to increase less rapidly, with an increase of velocity, than the friction of the particles of fluids among themselves.

18. *A new method of determining the Position of the Dipping Needle. Mém. Inst. Sc.* IV. P. 565. The method, suggested in a former memoir, is compared, in this short essay, with the mean of four observations made in the common way, the magnetism of the needle being reversed during the experiment; and it appears that the error of either method is not likely to exceed ten or twelve minutes.

19. *On Universal Magnetism. Bullet. Soc. Philom.* N. 61. 63. *Journ. Phys.* LIV. P. 240. 267. 454. *Journ. R. Inst.* I. P. 134. The experiments mentioned in the first of these papers were immediately repeated in this country, with results less satisfactory than those which Mr Coulomb had obtained; and he soon found reason, upon a further examination, to change the opinion which he had at first inferred from them, observing that a grain of iron was sufficient to communicate sensible magnetism to twenty pound weight of another substance. There still remain, however, some difficulties respecting the magnetism of brass, which have not

yet been sufficiently explained, and which have been mentioned in the article CAVALLO of this *Supplement*.

Mr Coulomb's moral character is said to have been as correct as his mathematical investigations. At an early period of his life he gained the grateful acknowledgments of the inhabitants of Britanny, for his disinterested exertions, in preventing the execution of some public works which threatened to be ruinous to the province. His manners were serious, but gentle, and sometimes diversified by a mild gaiety, which made him very amiable in society. His disposition was generous and benevolent; but, notwithstanding all his modesty, he could exhibit sufficient spirit, when he was called upon to repel an unjust attack. Such occurrences were, however, far from being frequent, for his merits and his success were universally acknowledged, and he was extremely popular, without ever having excited envy. In the particular department of science which he cultivated, he may fairly be ranked in the same class with Franklin, Æpinus, and Cavendish. He was less original than Franklin, but much more profound. He gave to the speculations of Æpinus both a more defined application, and a more satisfactory demonstration; and he was equally accurate with Cavendish, but much more persevering with respect to the more limited objects of his researches; and his improvements in the theory of electricity, may be considered as having immediately prepared the way for the elegant inventions of Volta, and the still more marvellous discoveries of Davy. In short, among all the men of science who have done honour to France, it would be difficult to point out a single individual who, with regard to the cultivation of terrestrial physics, could at all be put in competition with Mr Coulomb. His health had long been extremely feeble, and in addition to his more chronic complaints, he was at last attacked by a slow fever, to which he fell a victim on the 23d of August 1806. He had been a Lieutenant-Colonel of Engineers, a Chevalier of the Order of St Louis, and a Member of the Legion of Honour; but he had acquired little property; and he left to his two sons scarcely any other patrimony than the public gratitude and esteem, for his merits and his virtues. (Delambre, *Mém. Inst. Sc.* 1806, ii. *Hist.* P. 206.)

(U. N.)

CRANIOSCOPY.

Definition.

CRANIOSCOPY, or the inspection of the cranium, is a term recently invented to express the study of the external form of the skull in men and animals, with the view of ascertaining the form, size, and respective functions of the subjacent parts of the brain, and of deriving from thence indications relative to the natural dispositions, propensities, and intellectual powers of each individual. This science, whether founded on a real or imaginary basis, may be said to have originated with Dr Gall, a physician of Vienna, whose system, matured in conjunction with Dr Spurzheim, has of late attracted so much attention, and been so keenly discussed both here and on the Continent, that we think it our duty to present our readers with a general outline of its doctrines.

Physiology of the Brain imperfectly known.

Of the several parts which compose the human body, the mechanism of which has been so thoroughly unfolded by the diligence of modern anatomists, there are few whose use in the economy is wholly unknown. The intention and operation of every part of our frame subservient to the mechanical purposes of connection, of locomotion, and of strength, such as the bones, muscles, and ligaments, are, in general, sufficiently apparent; the functions performed by the abdominal and thoracic viscera, are, for the most part, well ascertained; and we are able, in like manner, to discern the adaptation of the organs of sense to receive appropriate impressions from surrounding objects. One organ alone, and an organ of vast importance in the system, connected with every other, and essentially interwoven with our sensitive existence, has baffled all investigation, and still presents a wide blank in this rich and cultivated field of knowledge. The brain, that large mass of pulpy substance, which fills the cavity of the cranium, is still as incomprehensible in its functions, as it is subtile and complex in its anatomy. It appears, indeed, to be sufficiently established, that the brain is, in some unknown way, subservient to sensation and voluntary motion, and is thereby the immediate agent by which the soul and body mutually exert an influence over each other. And it has also been very generally supposed, that this organ is immediately concerned in all our mental operations, besides being the instrument by which we feel and act. But the phenomena comprehended under the operations of the mind, are exceedingly various and complicated, and are also of very different kinds; so that before we can reason concerning them, it is necessary that they should be properly distinguished and arranged. Metaphysicians have, accordingly, classed them as referable to our sentient, our intellectual, our active, and our moral powers. Further subdivision again is required; and the intellectual phenomena, for instance, are arranged according as they relate to the faculties of conception, association, memory, abstraction, judgment, imagination, invention, &c. Other phenomena are distributed under the heads of the different active principles, such as the propensities, the instincts, the affections, and the passions, which belong to our nature. While we thus discover a great diversity in the functions of the mind, we observe also as great a complexity of structure in the organs by which they are performed. Shall we rest satisfied with an acquiescence in the general proposition, that the brain is the organ of thought? May we not rather regard it as a congeries of distinct organs, corresponding to the different faculties into which the mind may be analyzed; each organ having its appropriate office, and being im-

mediately subservient to some particular function of the mind? The question has, indeed, presented itself to many physiologists; but few have ventured farther in attempting its solution, than to throw out some vague and general conjectures as to the uses of certain parts, or as to the supposed habitation of the sentient principle. Thus, for a long period it was held, that the cerebrum was the organ of perception, and the cerebellum the organ of memory. The cavities which are met with in the interior of the brain have often been considered as the scene of the intellectual operations. Nemesius, the first bishop of Emesa, under the reign of Theodosius, taught that the sensations had their seat in the anterior ventricles, memory in the middle, and understanding in the posterior ventricles. Albertus Magnus, in the thirteenth century, went so far as actually to delineate upon a head the supposed seat of the different faculties of the mind. He placed common sense in the forehead, or in the first ventricle of the brain, cogitation and judgment in the second, memory and moving power in the third. Peter de Montagnana, in 1491, published the figure of a head, on which were indicated the seat of the *sensus communis*, the *cellula imaginativa*, *cellula æstimativa seu cogitativa*, *cellula memorativa*, and *cellula rationalis*. Ludovico Dolci, Servito, and a great number of other writers, have hazarded similar hypotheses as to the locality of the different faculties. Both Haller and Van Swieten fancied that the internal senses occupy different places in the brain; but they considered its whole organization as too complicated, too intricate, and too difficult, to allow of any hope that the seat of memory, of judgment, or of imagination, could ever be detected.

History of Dr Gall's Speculations.

In the pursuit of this speculation, no one has engaged with more ardour and perseverance than Dr Gall, who, after many years of patient labour, and much fruitless wandering in search of the truth, conceives that he has at last discovered the clue which is to conduct us through the mazes of this labyrinth, and enable us to arrive at a more accurate knowledge of human nature, and of the means which may conduce to its perfection. The account which he gives of the circumstances that gradually drew his attention to the subject, and of his progress in this new path of discovery, is as follows: Brought up in the midst of a numerous family, and naturally gifted with the talent for observation, he was struck, even when a boy, with the diversities of disposition and of character among his brothers and sisters, and the companions with whom he was educated. He remarked that each excelled in a particular study, or was distinguished by a peculiar turn of mind. One was noted for the beauty of his handwriting; another for his quickness at arithmetic; a third for his aptitude in learning languages; a fourth for remembering every thing that he read in history. This diversity was apparent in all that they did; thus the style of composition of the one was remarkable for its flowing and elegant periods; of another for its baldness and dryness; of a third for its condensation and vigour. Many displayed talents for arts which had never been taught them; they excelled, perhaps, in drawing, or in the execution of works of mechanism; some sought for amusement in noisy sports, others preferred cultivating their gardens; a few placed their chief delight in rambling through fields and forests, and in collecting birds, insects, and flowers. One was of a social and affectionate disposition, another was selfish and reserved; a third was fickle, and not to be depended upon. The great facility with which some of his school-fellows could commit their tasks to memory, which to him was a work of immense labour, although in matters of reasoning and judgment he felt himself their superior, often proved a grievous source of mortification, and excited in him a strong desire to know the cause of this difference. He at length remarked, that all the boys gifted with this kind of memory had large and prominent eyes. He afterwards went to the university; and directing his attention to all those among his fellow students, who presented the same peculiarity of feature, he learned that they were all distinguished by the tenacity of their memories; as, indeed, he soon found to his cost, for they were sure to leave him far behind in every competition, where the exercise of this faculty was essential to success. This observation gave rise to others; it suggested the notion, that other intellectual endowments might also be indicated by the features; and Gall, by degrees, came to imagine that he had discovered a number of external signs, which respectively indicated a decided turn for painting, for music, for mechanical arts, or other objects. He had by this time commenced the study of medicine; and, in the course of his academical instructions, he heard much about the functions of the muscles and viscera; but nothing was taught about those of the brain and its different parts. It then occurred to him, that the differences he had already noticed in the external configuration of the head, as connected with certain dispositions of mind, were occasioned by differences in the form of the brain. Delighted with the prospect which this idea opened to him of discovering the functions of particular parts of this organ, and of obtaining an insight into the connection between the mind and the body, he formed the resolution of prosecuting the research, till he had either accomplished his object, or satisfied himself that it was not to be attained by that method. Natural history, which had long been his favourite study, furnished ample scope for the extension of these inquiries. He had been in the practice of collecting plants and animals of various kinds, and of arranging them, not according to the artificial methods of classification detailed in books of science, but according to their more obvious resemblances. He now studied the relations between their external forms, and their natural habits and dispositions. Dogs showed him the greatest diversities in their capability of being educated. He remarked that some were naturally expert at the chace, while others, of the same breed, could not be trained without the utmost difficulty: that some perpetually lost themselves, while others found their way home from great distances. In birds, he observed that one would listen with attention to a tune which it heard, and immediately learn it; while another of the very

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same brood would sing nothing but the note that was natural to it. Whence, he would ask himself, can arise this wide diversity among individuals?

Progress of his Researches.

The solution of this difficult question was not to be hoped for, unless by means of observations conducted on the largest possible scale. He therefore set about examining all the skulls he could lay hold of, that had belonged to individuals whose history was known. He looked out for all persons in any way distinguished for a particular talent or moral quality. He examined their heads with great attention, and noted the peculiarities in their shape. He also collected observations on other individuals, who were remarkable for the weakness of any faculty, and then compared together the positive and negative indications. On the other hand, when he chanced to meet with a head that presented some singularity in shape, he was at much pains to obtain information as to the moral and intellectual character of the person to whom it belonged. When he had no other resource, he did not scruple, as Dr Spurzheim informs us, to address his questions directly to the person in whose head he observed any distinct protuberance. We are also told, that he was in the habit of collecting around him the boys he met with in the streets of Vienna, and of inducing them, by petty bribes, to confess their own faults, and betray those of their companions. He excited them, for instance, to fight together, in order to discover which possessed most courage, and thence drew inferences as to the organ which prompted that sentiment. In order to obtain more precise data for his conclusions, he endeavoured to procure models of the more remarkable heads that he met with, and generally got permission from the individuals themselves to take a cast of their heads in plaster of Paris. The Count of Sauran, then minister of police at Vienna, gave him material assistance in effecting these objects; and he was thus in no long time in possession of a very large collection of casts, all bearing more or less upon the several points of his theory. If he happened to hear of the death of any one whose head he had already moulded, he was at great pains to procure his skull, that he might compare the form of its different parts with the shape of the head during life. As it was soon known that the doctor aimed chiefly at those who possessed some remarkable talent, a very general alarm spread itself among the inhabitants of Vienna; and not a few were pursued with the terror of being selected as the subjects of cranioscopical investigation, and of their skulls being destined to make a figure in his anatomical cabinet. The aged Mr Denis, Librarian to the Emperor, is said to have inserted an express clause in his will, to protect his head from the keen scalpel of Dr Gall. Notwithstanding these fears and precautions, he contrived to amass an extensive collection of skulls, as well as of heads, in illustration of his doctrines. He next availed himself of the aid of comparative anatomy; and having no family to provide for, spared no expence in procuring skulls of all sorts of animals, with a view of tracing the form and size of corresponding organs throughout the whole series. Being physician to the establishment for the *deaf and dumb* at Vienna, he had opportunities of observing the natural features of uncultivated minds, and the various degrees in which they were susceptible of education. With the same view, he used to call together into his house persons of the lowest class, such as coachmen, and beggars in the street, and excite them to display their characters before him. His professional practice made him acquainted with a great number of families, and afforded him many opportunities of making valuable observations. He neglected no means of instruction that could be derived from the inspection of the heads of patients labouring under different forms of insanity. He was physician to the director of establishments for education, and was allowed to examine every child who excelled, or showed any remarkable disposition. He visited the prisons and houses of correction, as well as the hospitals for idiots and lunatics. He took casts of the heads of criminals, inquired into the offences for which they were confined, and collected the history of their lives: and thus derived from every quarter materials for bringing his theory to perfection.

As his observations multiplied, he became sensible that he had fallen into many errors in the earlier period of his inquiries, and was forced to give up many of his favourite opinions, which he found had been too hastily adopted, with regard to the general form of the head, as connected with the character of the individual. He felt the necessity of being in future more upon his guard, and resolved to institute a separate examination of the different regions of the skull; and although he was here, also, frequently obliged to shift his ground in assigning the function of each part, his researches were, on the whole, attended with more uniform success. By degrees he acquired greater confidence in the stability of his conclusions, and at length ventured to announce them to the public, by the delivery of lectures on his new science. His doctrines were eagerly received, and much canvassed at Vienna; but their fame had no sooner reached the Austrian court, than a violent outcry was raised against them by the bigoted priests, who controlled all the operations of that weak and misguided government, and who represented these doctrines as tending to materialism and atheism. The consequence of this senseless clamour was, that Gall was interdicted from lecturing. But the number of those to whom he had communicated the principles of his art, and in whom he had infused a strong desire to continue to profit by his instructions, was by this time very considerable, especially among the strangers who happened to be at Vienna. They formed a strong party in his favour, and made such interest at court, principally through the medium of the foreign ambassadors, that the doctor was again permitted to resume his prelections, on condition that he delivered them to foreigners only; as it was wisely considered that their being exposed to the dangers of knowledge, would not be of any material consequence to the state, so long as care was taken that the infection did not spread farther; and that the Emperor kindly preserved the bliss of ignorance for the exclusive enjoyment of his Austrian subjects.

His Lectures.

Publications,

It was long before Gall committed himself by writing on the subject that had procured him so

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much celebrity. He merely announced, in 1798, in a letter addressed to Baron Retzer, which appeared in the *Deutsche Merkur* of Wieland, his design of publishing a large work on the new theory, of which he affords his readers only an imperfect glimpse. A detailed account was afterwards given by M. Froreiss, one of his pupils, in the second volume of Voight's *Magazin Physique ;* and an amusing outline appeared from the pen of M. Charles Villers, in a letter addressed to Cuvier. Various surreptitious copies of his lectures were also circulated throughout the Protestant states of Germany, where they excited so much curiosity, that Dr Gall was at length induced to make a tour for the purpose of delivering them himself at the principal universities in the north of Germany. With this view he visited Dresden, Berlin, Hallé, Jena, Weimar, Göttingen, Hamburg, &c., and every where met with the most flattering reception, being invited to the several courts of the states through which he passed, and treated with the honours due to a distinguished literary character. By frequenting the first societies, and conversing with the best informed persons, he had ample opportunities of extending his observations, and he was attentive to improve these opportunities to the utmost of his power. Dr Spurzheim, who had at an early period been associated with him in these inquiries, and who had devoted himself particularly to the anatomical researches they comprised, accompanied him in this tour, and participated in all his labours. Dr Gall at length settled in Paris, where he still continues his pursuits and lectures, and unites with them the practice of his profession.

and Travels.

In 1810, Drs Gall and Spurzheim published, in conjunction, the first volume, in quarto, of the work they had announced, and which was to contain a full account of their doctrines, under the title of *Anatomie et Physiologie du systême nerveux en général, et du cerveau en particulier, avec des observations sur la possibilité de reconnoitre plusieurs dispositions intellectuelles et morales de l'homme et des animaux, par la configuration de leurs têtes.* The first part of the second volume appeared in 1812. This work, together with the one published in 1815, by Dr Spurzheim, entitled, *The Physiognomical System of Drs Gall and Spurzheim, founded on an anatomical and physiological examination of the nervous system in general, and of the brain in particular, and indicating the dispositions and manifestations of the mind,* contain the only authentic account of their system. Information on the subject may, however, be derived from the following books, besides those of Froreiss and Villers, already mentioned. The best of the foreign works is that of Professor Bischoff, entitled *Darstellung der Gall' schen Gehirn- und Schädellehre, nebst Bemerkungen über diese Lehre, von D. W. Hufeland,* Berlin, 1805. At Dresden, in 1806, Bloede published a similar work, *Galls Lehre über die Verrichtungen des Gehirns, nach dessen zu Dresden gehaltenen Vorlesungen ;* and at Paris, in the same year, we have, from the pen of Démangeon, *Physiologie intellectuelle, ou développement de la doctrine du Professeur Gall.* A small tract in English, entitled, *Some Account of Dr Gall's new Theory of Physiognomy, founded upon the Anatomy and Physiology of the Brain, and the Form of the Skull,* appeared in London in 1807; and is chiefly taken from Dr Bischoff's work, including the critical strictures of Dr Hufeland. Soon after the publication of Dr Spurzheim's book, a small volume, principally reprinted from a short tract in the *Pamphleteer,* was given to the public by Mr Thomas Forster, under the title of *Sketch of the New Anatomy and Physiology of the Brain and Nervous System of Drs Gall and Spurzheim, considered as comprehending a complete system of Zoonomy, with observations on its tendency to the improvement of education, of punishment, and of the treatment of insanity.* Two pamphlets in opposition to these doctrines were published by Professor Walter of Berlin, in 1805, of which, as well as of Bischoff's work, a short account is given in the *Edinburgh Medical and Surgical Journal* for July 1806. Dr Spurzheim having conceived that he was unfairly attacked in some of the Reviews, thought proper to publish a reply, in a pamphlet which made its appearance at Edinburgh in 1817, entitled, *Examination of the Objections made in Britain against the doctrines of Gall and Spurzheim.* These, together with the lectures delivered in London by Dr Spurzheim, are the sources which have supplied the materials for the following summary.

Other Works on his System.

It is laid down both by Gall and Spurzheim as the foundation of their doctrines, that the nature of man, like that of all other created beings, is determinate, and that the faculties with which he is endowed are *innate ;* that is, that they are implanted in him at his first formation, and are not the result merely of the external circumstances in which he may afterwards happen to be placed, nor of the wants and necessities to which these circumstances may have given rise. They warn us that this opinion is by no means at variance with that of Locke, who argues only against the innateness of ideas, and not of the faculties or capacities of receiving ideas. Education, doubtless, has a powerful influence in modifying and giving certain directions to these faculties ; but the faculties themselves, that is, the capacities of feeling, of intellect, and of action, must have already pre-existed before they could be called into play, and thus produce the various phenomena which diversify the scene of human life. Savages have been found in woods destitute of all the ordinary faculties of rational beings. Their resemblance to brutes has been supposed to be the consequence of their total want of education ; but, when we come to examine into their real condition, we shall find that they are wretched beings, with great bodily defects ; for the most part deeply tainted with scrofula, and almost always complete idiots. In general, they appear to have been abandoned in their childhood by their parents, to whom they were burdensome. The pretended savage of Aveyron, who is kept in the Institution for the Deaf and Dumb at Paris, is almost completely idiotical. He is quite deaf, and his head and body are incessantly in motion from side to side, even when he is sitting.

The Human Faculties innate,

In estimating the causes of that diversity which we see prevailing in the characters and faculties of

and originally different in each Individual.

Cranioscopy. individuals, much has been ascribed to the influence of diet, mode of living, and the impressions received in early infancy, while all the organs are yet tender, and highly susceptible of every kind of external influence. But the operation of these causes, as well as the power of education in general, is much too limited to explain the immense differences we observe among different men, and even among different children of the same family. Helvetius and other bold metaphysicians have maintained the paradox, that all men are born originally the same, and are moulded into what they afterwards become solely by the force of external circumstances. Genius, according to this doctrine, is a mere creature of the fancy, and originally belongs no more to one man than to another. Train all men alike, and their powers, their attainments, and their actions, will all be similar. Accident, more than design or premeditation, has fixed the destinies of great men, as well as disposed of those who are unknown to fame. "Demosthenes," say these philosophers, "became eloquent, because he heard an oration of Callistratus, whose eloquence made so deep an impression on his mind, that he aspired only to acquire this talent. Vaucanson excelled in mechanics, because, being obliged, when a child, to stay alone in the waiting room of his mother's confessor, he found there a clock, examined its wheels, and endeavoured, with the help of a bad knife, to make a similar machine of wood. He succeeded; and one step leading on to another, he arrived at the construction of his wonderful automatons. Milton would not have composed his *Paradise Lost*, had he not been deprived of his place of secretary to Cromwell. Shakspeare composed his tragedies because he was an actor; and he became an actor because he was forced to leave his native place on account of some juvenile errors. Corneille fell in love, made verses for the object of his passion, and thence became a great poet. An apple fell from a tree at the feet of Newton, while he was in a contemplative mood; this event, so trivial in itself, led him to the theory of gravitation." Reflections of a similar kind are often met with in the writings of poets and moralists. Those contained in Gray's *Elegy* must be familiar to all our readers. Dr Johnson considered talents or genius as a thing that, when once existing, might be directed any way. Newton, he thought, might have become a Shakspeare, for, said he, a man who can run fifty miles to the south, can run fifty miles to the north.

Yet these are but the ingenious speculations of the theorist, more calculated to dazzle than to convince, and obviously in contradiction with the daily experience of mankind. Original differences in the constitution of the mind, exist as certainly as in that of the body; and doubtless are dependent upon differences in organization. Children often show, from their earliest infancy, the germs of those peculiarities of character which adhere to them through life, which hardly any education can alter, and which no condition of life or variation of circumstances can afterwards affect. It is needless to expatiate on the subject of the diversities of intellectual powers exhibited by different individuals under the very same circumstances of birth and education; diversities which, as we have already seen, first directed the mind of Dr Gall to his physiognomical researches. Many of these peculiarities are unquestionably derived from the parent, and are observed to prevail in certain families, and to descend through several successive generations.

The Mental Faculties are not exercised by the Nerves alone;

That no sensation, or other affection of the mind, and that no operation of intellect can take place without a certain condition of the nervous system, is a position established by so many direct proofs, that its truth must be generally admitted. The question becomes more difficult when we come to inquire into what part of the system it is that exercises these functions. It is quite clear that the sentient principle does not reside in the nerves, or in the part which receives the first impression from the external cause of sensation. The opinion which has been embraced by many physiologists, and particularly Bichât, that while the brain is the organ of the intellectual faculties, the nerves of the great viscera of the abdomen and thorax are the seat of the moral sentiments, is at variance with a multitude of facts in comparative anatomy. There are animals endowed with the faculties ascribed to these nervous plexuses, or ganglions of the great sympathetic nerves, distributed to certain viscera, which have not the viscera in question. On the other hand, most quadrupeds have viscera analogous in their whole structure to those in man, without having the faculties of which in man it is pretended they are the seat. We have a complete series of proofs that the nerves, of themselves, and without an uninterrupted continuity with the brain, can produce neither sensation nor voluntary motion.

but are dependant on the Organization of the Brain.

Compression of the brain, by any cause, produces an entire suspension of all sensation and consciousness, and a complete stop to every operation of intellect. All the other parts of the body, on the other hand, may be wounded or destroyed, and even the nervous mass of the spinal marrow may be compressed or injured, at a certain distance from the brain, without the immediate destruction of the feelings and intellectual faculties. In tetanus, produced by a cause remote from the brain, the other nervous systems are affected in the most violent manner, while the functions of the mind continue unimpaired.

Proved by its Developement;

In children, Dr Spurzheim observes, the brain is yet pulpy, and the faculties imperfect; its growth accompanies their improvement; its maturity marks their greatest degree of vigour. If its developement has been considerable, the manifestations of these powers is energetic; if small, they are comparatively weak. In proportion as the organization of the brain decreases, the strength of the moral sentiments and intellectual faculties decreases also. If the developement of the brain take place too early or too late, the faculties exhibit corresponding variations. Certain faculties are more active in men, and others in women, according to the difference of their cerebral organization; and peculiarities of character are hereditary, according as the corresponding organization of the brain, on which they depend, is propagated from parents to their children.

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by Injuries and Diseases;

Although many facts show that considerable injuries may be sustained by the brain without detriment to the mental faculties, yet as a general principle, it is contended by Dr Spurzheim, that these faculties are weakened or destroyed in proportion as the brain is mechanically altered. It is, however, certain, that physiologists are by no means agreed as to this point; and that innumerable cases might be quoted in direct contradiction to this principle. These are attempted to be explained away by the general supposition, that most of them are the result of very inaccurate observations, in which the statement of the facts has been distorted and vitiated by ignorance, prejudice, or credulity; and that the rest are inconclusive as to the general question, from the observers not being aware of the real functions of the injured parts, and being inattentive to the circumstance, that almost all the parts of the brain being double, the loss of those on one side would scarcely be felt, so long as the corresponding organs on the other side remained entire. On the other hand, it should be recollected, that a derangement in an organ may occur of such a nature as that our senses cannot enable us to discover it. How often is this exemplified in fatal diseases of the nervous system, such as hydrophobia, tetanus, and atonic gout. Analogy shows us other parts where no proportion is preserved apparently, between the injury and the derangement of function. Sometimes large abscesses are met with in the lungs without much disturbance of the function of respiration; and ossification of the heart, without any sensible affection of the circulation. In persons possessed of great irritability, very slight wounds of the brain may produce serious effects, while considerable wounds in others, who are less irritable, shall be attended with no bad consequences. This consideration will go a great way towards explaining the fact, that in many cases of insanity, instead of our discovering any change in the brain, a diseased state has been observed in the liver, the bowels, and other viscera; and may serve as an answer to the assertions and objections of Pinel, who states that the most accurate dissections have not taught us any thing with regard to the seat of mental alienation, and that we have no sufficient data to conclude, from diseases of the brain, that it is exclusively the organ of the intellectual faculties.

by Dissections in Hydrocephalus;

Those who have opposed the theory of the subserviency of the brain to the operations of mind, have laid great stress upon an argument derived from the phenomena of hydrocephalus. In patients afflicted with this disease, the brain appears to be completely destroyed, and replaced by water; and yet the intellectual and moral faculties have remained perfect to the last. Drs Gall and Spurzheim conceive, that the facts have been very erroneously represented; and that the only alteration which the brain sustains in these cases, is a displacement of its parts, and not an absorption of its substance. The effused fluid, by accumulating in the ventricles, gradually unfolds the convolutions of the hemispheres of the brain, and expands them to such a degree, that they are reduced to a thin stratum of substance, constituting a sort of bag, within which the fluid is still contained. This stratum of brain is sometimes not more than a line in thickness, and is generally lacerated in attempting the dissection; in which case the water rushes out, the real structure escapes notice, and the fluid is erroneously supposed to have been accumulated between the brain and its membranes.

by Monsters

It has been advanced, as another objection to the same theory, that monsters are sometimes born without any brain, who yet suck and perform various movements. Actions of this kind, however, are purely automatic, and appear to be unattended with consciousness; with such actions the brain has no concern whatever. Some have founded their opposition to the theory, on the result of some experiments of Duverney on pigeons, which, it is alleged, continued to perform all their animal functions after the whole of the brain had been removed from the skull. But Dr Spurzheim, on repeating these experiments on birds and rabbits, found, indeed, that the destruction of the superior parts of the brain does not destroy the functions of the five senses and of voluntary motion, but that it was impossible to take out all the cerebral mass without killing the animal. As soon as the *corpora striata* and optic *thalami* were wounded, convulsions and death ensued; consequently he does not hesitate to pronounce the account given by Duverney to be entirely false. He, in like manner, wholly discredits the stories related by Morgagni, Zacutus, Lusitanus, Bartholine, Haller, Vallisneri, Moreschi, Giro, Dr Simson, Sœmmerring, and others, concerning petrified or ossified brains being found in individuals, without prejudice to the exercise of their intellectual faculties. He admits it to be doubtful, how far, in perfect animals, the brain may be necessary to the passive consciousness of the external senses; but deems it certain, that the exertions of will, including voluntary motion and reflection, depend entirely upon the brain; no phenomenon of this kind ever taking place without that organ.

and by direct Experiment.

Hypothesis of the Plurality of Organs.

Concluding, therefore, that the brain is the organ of the sensitive, the intellectual, and the moral faculties, we have next to inquire, whether these faculties are exercised in common by the whole, or any particular portion of the brain, or whether, on the other hand, they are more especially the offices of different parts of that organ. Dr Gall adopts the latter of these opinions, and upon this view of the subject is the whole of his system founded. The following is the reasoning on which he builds it.

Arguments in its favour derived, from there being no assignable *sensorium commune*;

Physiologists, influenced by the metaphysical tenets of the schools, have often maintained, that the soul, being simple, its material residence must be simple also, and that all the nerves must end in one point; or, which amounts to the same, that they can have but one common origin, because each individual has but one soul. Bonnet, Haller, and others, who had extended its seat to the whole substance of the brain, were opposed by these metaphysicians, who did not reflect that a little more or less room could not enable them to explain any better the nature of the soul; nor that, as Van Swieten and Tiedemann remark, a material point, in which all ideas and sensations should centre, is inconceivable, in

 consequence of the confusion and disorder that would result from such an arrangement. It appears ridiculous, indeed, that the physiologist, to whom all nature is open, should direct his researches and inductions by the guidance of such frivolous speculations. Great pains were, however, taken to determine this central point, or *sensorium commune;* but it is enough to enumerate the various and contradictory opinions that have been held with regard to it, in order to be satisfied of the utter futility of this research. Descartes, in his treatise on the *Passions*, labours to prove, that the soul is concentrated in the pineal gland. This hypothesis continued in fashion for some time, till it found an enemy in a follower of Descartes, the Dutch physician Boutekoe, who dislodged the soul from its narrow watch-tower in the pineal gland, and confined it in the more spacious prison of the *corpus callosum*. Lancisi, Maria, and La Peyronie, successively declared themselves in favour of this new opinion; and the latter of these anatomists wrote a memoir in support of it, which was printed by the Academy of Sciences in 1741, and which has since been republished separately. Digby next transferred the soul to the *septum lucidum*, in place of the *corpus callosum*. Vieussens allowed it greater latitude, assigning for its boundaries those of the *centrum ovale* of the medullary substance. Willis, again, restricted it to the *corpora striata*; Serveto, to the aqueduct of Sylvius. Wharton and Schellhammer placed it in the commencement of the spinal marrow; Molinetti and Wrisberg in the *pons Varolii;* Crusius and Meig in the origin of the *medulla oblongata;* while Drelincourt and others lodged it altogether in the cerebellum. Lastly, Sœmmerring imagined the soul to reside in the serosity which moistens the inner surface of the ventricles, to which he had traced the extremities of many nerves from the organs of sense; and conceives that the different motions or oscillations of this fluid are the immediate material cause of our sensations.

Discarding the notion that the functions of sense and intellect are concentrated in any particular point or portion of the brain, let us next examine the opinion, that all the faculties are exercised by the whole mass of brain considered as one organ. We may, in the first place, remark, that the analogy of other parts of the system is adverse to this hypothesis.

from various Analogies;

Every different secretion has its appropriate gland, the offices of which are never interchanged. The liver never secretes urine, nor the kidneys bile. The five external senses are distinct and independent of one another. Every where do we observe that nature, in order to produce various effects, has varied the material organs. The structure of the brain in its different parts is far from being simple and uniform; it is composed of two substances; the one soft, pulpy, and ash-coloured; the other white, opaque, and fibrous in its texture. The fibres of the latter run parallel to each other, having, at the same time, various collateral connections, but by no means uniting in any one central part, that can be considered as their common origin or termination. The parts of the brain are numerous, and distinct from one another, bearing evidence of a very complex and artificial construction. They are constant in their general arrangement in different subjects, showing in this respect a striking contrast with the distribution of blood-vessels, or even the disposition of the muscles and viscera, in which it is so common to meet with variations. Comparative, as well as human anatomy, furnishes strong analogical arguments in favour of the plurality of the cerebral organs, corresponding to the plurality of faculties. However defective may be our knowledge of the structure of these organs in the lower animals, still a general comparison of their faculties, as we ascend in the scale of being, shows us that the number of these faculties increases in proportion as the cerebral parts are multiplied. The immense augmentation of the powers of intellect which we behold in man, when compared with the limited instincts of animals, is neither in proportion to the increased size of the five external senses, nor of any other part of the body, but to the increase of the cerebral organs only. It is the great size of the hemispheres of the brain, more especially, that characterizes this organ in man, and establishes its superiority, as an instrument of intellect, over that of all other animals. Man unites in himself all the organs which are variously scattered and distributed among the brute creation; but he has also organs in his brain, which no other animal besides himself possesses, and these are the seats of faculties of a higher order, peculiar to him alone.

from the diversity of Characters among Men;

Considerations arising from the differences in the proportional energy with which the faculties manifest themselves in different individuals, are also in favour of the plurality and independence of the organs. If the brain were one simple organ of mind, and alike instrumental in all its faculties and operations, wherever we met with any one faculty in a state of high energy, we must suppose the organ adapted to produce this degree of energy, and ought to expect its other operations to be equally energetic. Yet we may find the same individual remarkably deficient in other faculties, which are equally dependent on this organ. One person shall excel in verbal memory, while he cannot combine two ideas philosophically; another is a great painter, but a bad musician, or a wretched poet. Another is a good poet, but a bad general. If the brain be a single instrument it cannot be at once both weak and strong; it cannot exhibit one faculty in its perfection, and another in a very limited extent. But all difficulty vanishes if we admit it to be an assemblage of many organs; for the combination of these organs may be as infinitely diversified as the actions and powers of man. The argument derives additional force from the readiness with which this theory may be applied to explain the diversity of character we meet with in the brute creation, and especially to the varieties of disposition observable among some of our domestic animals, which, under the same circumstances of education, exhibit such different qualities. In like manner, the diversity of character in the same individual, at different periods of his life, are most readily explicable on the supposition of distinct organs, which have their respective periods of growth, maturity, and decline. The analogy of the external

senses is also strongly in favour of the same doctrine: thus the taste and smell appear earlier than the senses of seeing and hearing, because their respective organs are earlier developed. This reasoning will be confirmed when it is found, as will afterwards be shown, that the proportional size of the different parts of the brain is very different in different individuals. Is it not, therefore, reasonable to suppose, that the different energies of the several functions of the mind are connected with these differences in the structure of the organs which respectively produce them?

from the Analogy between Mental and Bodily Fatigue;

The faculties of animal life are incapable of long continued exertion; rest is necessary for the renovation of their powers. Fatigue is the consequence of the prolonged action of the muscles of voluntary motion; but when one set of muscles are fatigued, the power of others is still unimpaired, and they are ready to be employed in a different action, without any additional fatigue. When we have been long sitting, we are relieved by standing; and even the bed-ridden find ease from a change of posture. Our eyes, in like manner, may be fatigued by looking at pictures; but we can then listen to music, because there is one organ for seeing, and another for hearing. It is well known that study, long protracted, produces fatigue; but we can continue to study, provided we change the object of attention. If the brain were a single organ, the whole of which was employed in performing all the functions of mind, a new form of study should increase instead of relieving the sense of fatigue. Thus the analogy is complete between the phenomena of mental and bodily exertion: are we not, then, justified in extending it to the instruments by which these operations of mind and body are effected?

from the Phenomena of Sleep, Dreaming,

The phenomena of sleep are also readily accounted for on this hypothesis. During this state all the organs do not remain inactive; but sometimes a particular organ enters into action, and this constitutes dreaming. The state of vigilance is that in which the will can put in action the organs of intellectual faculties, of the five senses, and of voluntary motion; but it is incorrect to define it as the state in which all these organs are active, for it is impossible that all the faculties should be active at the same moment. Somnambulism may be regarded as a state of still more incomplete sleep, or one in which several organs are watching. If, during sleep, the action of the brain is partial and is propagated to the muscles, locomotion takes place; if to the vocal organs, the sleeping person speaks. All this may take place in different degrees. Some persons dream and speak in their sleep; others dream, speak, hear, and answer; others, besides dreaming, rise, walk, and do various things. This latter state is called somnambulism; that is, the state of walking during sleep. Now as the ear can hear, so the eyes may see, while the other organs sleep; and there are undoubted facts which prove that several persons in the state of somnambulism have seen; but it has always been with the eyes open. There are also convulsive fits in which the patients see without hearing, or *vice versa*. Some somnambulists do things of which they are not capable in a state of watching; and dreaming persons reason sometimes better than they do when awake. This phenomenon is not astonishing. If we wish to reflect upon any subject, we avoid noise, and all external impressions; we cover the eyes with our hands, and we put to rest a great number of organs, in order to concentrate all vital power in one, or in a few. In the state of dreaming and somnambulism this naturally happens; consequently the manifestations of the active organs are then more perfect and more energetic; the sensations are more lively, and the reflections deeper than in a state of watching.

and Somnambulism;

from States of Disease;

States of disease are also adduced as proving the plurality of the cerebral organs. In many cases of insanity we find only one faculty deranged, while all the rest are in a perfectly sound state. Lunatics, on the other hand, are met with, who are reasonable only while pursuing some particular train of thought. There was a chemist, for instance, who was insane on every subject except chemistry. An embroiderer, during her paroxyms of insanity, while uttering the greatest absurdities, calculated correctly how much stuff was necessary to such or such a piece of work. The effects of blows, or other injuries on the head, supply facts of a similar kind, which afford still more convincing proofs that the brain is susceptible of being very partially affected. Some persons lose from this cause the memory of proper names, while they preserve the memory of words which indicate the qualities of objects. One Lereard of Marseilles, after having received a blow from a foil in the orbit, lost entirely the memory of names; sometimes he did not recollect those of his intimate friends, or even of his father. Cuvier, in his historical eulogium on Broussonet, states that this celebrated botanist, after having recovered from an apoplectic fit, never could recollect proper names nor substantives, though he had recovered his prodigious memory with respect to other objects. He knew plants, their figure, leaves, and colours; he recollected the adjectives, but could never recover the generic substantives by which they were designated. These and similar instances of partial affections of the faculties support the supposition of their being owing to different conditions of various parts of the brain subservient to these faculties.

and from Authorities.

Lastly, the doctrine that different portions of the brain exercise different mental functions, is countenanced by numerous authorities in former as well as in modern times. It is expressly stated in the writings of Boerhaave, Van Swieten, Haller, Prochaska, Sœmmerring, &c.; and the Academy of Dijon long ago proposed it as a prize-question, to determine the situation of these different cerebral organs. Charles Bonnet, indeed, went the length of maintaining that each fibre of the brain is a particular organ of the soul.

Charge of Materialism unfounded.

It seems hardly necessary to expose the absurdity of the accusation that these doctrines tend particularly to materialism, although the dread of such a consequence has been sanctioned by royal edicts. There are two opinions only, which, in respect to this question, stand opposed to each other; namely, that which asserts perception to take place by the intervention of a material organ, and that which as-

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serts it to take place immediately by the energies of the mind itself, or at least without the intervention of the body. The doctrines of Gall are unquestionably incompatible with this last opinion, that is, with pure immaterialism, which may in fact be regarded as denying the existence of matter altogether. This sceptical spiritualism can be avoided only by the admission of the necessity of a material organ; and if this be admitted, any modification of such opinion, that does not exclude mind as the ultimate percipient, must be equally remote from absolute materialism. The immaterialist believes that it is the soul which sees and the soul which hears, as much as that it is the soul which judges and the soul which imagines; and since he does not condemn, as impious, the allotment of different organs of sight and hearing, what greater heresy is there in the allotment of different parts of the sensorium as the organs of judgment and imagination? If, indeed, any one were to say, that the affections of these parts are themselves judgment and imagination, he would be a materialist, but he would be as much a materialist, if he should say, that the affections of the organs of sight and hearing are themselves the ideas of colour and sound.

Determination of the Functions of the Cerebral Organs,

Supposing it, then, established that each function of the mind is exercised by a separate portion of the brain, let us next inquire whether observation can furnish us with any means of determining the precise nature of the function, to which each particular organ is subservient. Although it is clear that the adaptation of each organ to the performance of its office, must be wholly dependant on its particular organization, yet it is equally evident that no consideration of its general structure, as shown to us by anatomy, can teach us *à priori* what such function really is, and still less what may be its degree of energy, or its peculiar quality and modifications. The energy of the function must in all cases depend on certain conditions of the organ, such as the perfection of its original constitution,—its elaborate texture,—its relative size, and the degree of exercise it has received; and will also be regulated by the influence which other faculties may exert on its operations. The only one among these conditions, which is open to observation, is the relative size of the organ. In general we find that the properties of bodies act with an energy proportionate to their size. A large loadstone attracts a greater mass of iron than a smaller loadstone. A large muscle, in like manner, is stronger than a small one. If the nerves of the external senses be larger on one side of the body, the functions are also stronger on that side. Comparative physiology shows us that the olfactory, optic, and auditory nerves of those animals which are distinguished for the excellence of their smell, sight, or hearing, are marked by being numerous and large, evincing a more elaborate developement. The coincidence is so uniform as to justify the general inference, that wherever any organ is met with in a higher state of developement, we may there expect to find the power dependant on it increased in energy in the same proportion. May not this analogy be fairly extended to the organs which compose the brain? Our present object, it must be recollected, is not to determine every degree of activity existing in a cerebral part, but merely the *nature* of its function; and for this purpose the indication afforded by its comparative size, in different cases, will suffice.

by their relative Size.

Process for conducting the Inquiry.

We may observe in different individuals a considerable variation in the proportional developement of different parts of the brain. It is reasonable to suppose, that the functions which are more developed in one person than in others, will be more active, and manifest themselves with more energy, than those which are less developed. Those which are comparatively small we may expect to be less active, and their powers more feebly exerted. Let us then select as the subjects of observation such persons as are marked by strong peculiarities of mind or character, and especially such as are endowed with a partial genius, as it is called; that is, who manifest in a very high degree any particular faculty of mind: let us note the peculiarities in the form of their heads, and observe what organs in them are of an unusually large size. By repeated comparisons we shall arrive at the knowledge of the particular organ in which that faculty resides. The converse method, on the other hand, must be pursued with those who betray a singular deficiency of power in any faculty. With such persons we must endeavour to discover what particular part of the brain exhibits an imperfect developement. The results of both these modes of determining the functions of each organ, when compared together, will correct, and, if just, will ultimately corroborate each other. Experience, multiplied and extended, will finally confirm and establish our conclusions, and complete the system in all its parts.

Correspondence in shape between the Skull and Brain.

But the living brain can never be exposed to observation, and, from the nature of its substance, loses much of its form and texture soon after death. It may appear impossible to discover the form or size of particular parts of the brain during life, since the whole mass is inclosed in the bony case of the skull, of which the thickness varies in different parts; and since the skull itself cannot be immediately inspected, being covered by muscles and integuments, which, by contributing to smooth all the inequalities of its surface, must preclude us from forming an exact estimate of its real shape. This obvious objection to the proposed inquiry, Drs Gall and Spurzheim labour to remove by the following considerations. If we attend to the successive stages of the growth of the skull, we find that its ossification begins at different points; that the bony processes extend in divergent lines, adapting themselves exactly to the form and size of the cerebal parts they are destined to inclose and protect. Whatever violence may be done to the bones of the skull during birth, they soon return to their natural state, partly from their elasticity, and partly from the inherent powers of the brain, which tend constantly to restore its original shape. The compression of the brain is besides of too transient a nature to produce any permanent change in the primitive forms either of the skull or the brain. If it ever amounted to what could irrecoverably derange the organization, and hinder its future developement, the necessary consequence of

such a degree of violence would be death or idiocy.

In the progress of its growth the increasing dimensions of the skull keep pace with those of the brain. All the cerebral parts do not increase simultaneously; and this partial developement is equally observable in the skull. The forehead, for instance, which at birth is narrow and flat, grows wider and more prominent from the age of three months to that of eight or ten years. After this period, the middle part of the forehead is less developed in proportion to the other parts. The neck of children is very small, because the cerebellum, which is situated at the inferior occipital *fossæ*, is not yet developed: but in proportion as this organ increases in size, the skull grows prominent at that part. The same happens with all the other cerebral parts which increase progressively. The shape of the skull cannot be in any degree influenced by external causes, such as occasional pressure in one direction, as happens in carrying burdens on the head, or artificial modelling of the heads of infants, as is asserted to be practised among the Caribs and other savage nations. In other parts of the body we may remark, that whatever soft parts are inclosed in bones, the shape of the latter is adapted to the dimensions of the former, and is regulated by the changes they undergo; the ribs, and even the spine, yield to the pressure of an abscess, or the growth of an aneurism: and the bones of the face, in like manner, make way for the increase of tumours, and adapt themselves to the new form these render necessary. By experience in feeling the living head, we may readily learn to distinguish the form of the bones which lie beneath the integuments. The observation of the shape of the skull, or of the head, is therefore capable of giving us exact information as to the relative size and shape of the different parts of the brain, and on the knowledge thus obtained is founded the art of Cranioscopy.

Practical Cautions.

In practising this method, however, it is necessary to guard against several sources of error. We must take into account several protuberances, which belong to the natural state of the skull, and which have some particular destinations foreign to the immediate functions of the brain; such as the mastoid processes behind the ears, the crucial spine of the occiput, the zygomatic processes, and the frontal sinuses. The cerebral parts, situated behind the orbits, indeed, require some exercise on the part of the organoscope, in order to be exactly determined. Their developement may be perceived by the configuration and position of the eyes, and by the circumference of the orbits. It is therefore necessary to examine whether the eyeball is prominent or hidden in the orbit, whether it is depressed or pushed sideward, inward, or outward. According to this position of the eyeball, we may judge that such or such part of the brain, which is situated against such or such part of the orbit, is more or less developed. The functions of those organs, which lie wholly at the basis of the brain, can be ascertained only by examination after death.

It may be objected. that the organs are not confined to the surface, or convolutions of the brain: but although this be the case, and although they really extend from the surface to the basis of the brain, or *medulla oblongata*, yet the degree in which they are expanded at the surface, where they form the convolutions, will indicate, in general, the relative magnitude of the whole organ. The analogy of the five senses, of which the peripheric expansions indicate the developement of their respective nerves, shows the reasonableness of this supposition. From a large eye, implying a large retina, or peripheric expansion of the optic nerve, we naturally infer that the nerve itself is of considerable magnitude: may we not draw the same conclusion with regard to the organs of the moral sentiments and intellectual faculties, whenever we find that the convolutions, which are their peripheric expansions, are much developed?

In feeling for the organ, Dr Gall recommends the use, not of the fingers, but of the middle of the palm of the hand; and declares that habit, as well as a certain natural delicacy of tact, is necessary to qualify a person to make these observations with certainty of success. We are warned also, to confine our observations to young and grown-up persons in the flower of their age; for at an advanced period of life the brain diminishing by degrees, and retiring from the skull, leads to the recession of its inner table, and consequent inequality in its thickness, which renders it impossible to judge exactly of the size or shape of brain from that of the head. Analogous changes occur in the skulls of some lunatics, and occasion similar difficulties in applying the rules of cranioscopy. It is also to be considered, that our aim is to distinguish the size, and not the mere prominence of each organ. If one organ be much developed and the neighbouring organ very little, the developed organ presents an elevation or protuberance, but if the neighbouring organs be developed in proportion, no protuberance can be perceived, and the surface is smooth.

We have already stated the mode in which Dr Gall proceeded to apply and to verify these principles: it is now time that we present our readers with the result of his labours.

Classification of Faculties.

He arranges the faculties of the mind, with their corresponding organs, according as they relate to the feelings and to the intellect: the first class comprehending the *propensities*, all of which are common to men and animals, and the *sentiments*, which constitute what the French denominate *l'Ame*, and the Germans *Gemüth:* and the second class comprising the faculties by which we acquire knowledge, or the *knowing faculties*, as he terms them; and also the *reflecting faculties*, which last compose what the French call *l'Esprit*, the Germans *Gheist*, and what we should generally understand by the term *intellect*. He finds that the organs of those faculties which men possess in common with animals, are situated towards the basis and back part of the brain; while those of the superior faculties, which are peculiar to man, are placed somewhat higher; and the organs subservient to the intellectual faculties occupy exclusively the forehead. The total number of special faculties is thirty-three, as may be seen by the following enumeration.

Organs of, I. Amativeness.

1. Of the faculties common to men and animals, the first is that physical propensity which has for its

final purpose the continuance of the species. The cerebellum, a part which occupies the lowest situation in the encephalon, is affirmed to be the organ, the actions of which give rise to this propensity. Accident led Dr Gall to this discovery, by his noticing the size of the back of the neck in a lady whose character, in respect to this passion, was not equivocal: and subsequent observation on an extensive scale, both in the human subject and in the lower animals, have abundantly confirmed him in his opinion. The following are the leading arguments on which he has rested it. First, the great size of the organ indicates the importance of the function to which it is subservient, and there is no cause, except the existence of such an organ in the brain, that is adequate to account for this propensity. The function of copulation takes place only in those animals which have a nervous mass or cerebellum. Throughout the whole class of quadrupeds, the neck of the male is thicker than that of the female, as may be observed particularly in the bull, the ram, and the stallion. It is also remarked that vigorous pigeons are distinguished by the size of their necks. The developement of the cerebellum is simultaneous with that of the genital organs at the period of puberty, and early castration prevents its developement, as well as that of the beard, and the organs of the voice. Wounds of the neck have been observed by Hippocrates to be sometimes followed by impotency. In other cases, however, they produce erotic excitement. Apollonius Rhodius, in speaking of the love of Medea, represents her as suffering a violent pain in the back of her neck. A case occurred to Professor Reinhold, at Leipzig, in which an excitement of the genital organs succeeded the introduction of a seton in the neck, in a boy who laboured under ophthalmia. Spirituous frictions on the neck in hysterical fits are very useful. Lastly, the position of the cerebellum is supposed to prove its destination. After hunger and thirst, no function is more necessary than that of propagating the species. This function is the most common in animals after nutrition, and the cerebellum is in the inferior part of the head. Hence it is probable, that it is destined to the propensity of propagating, or that it is, as Dr Spurzheim expresses it, the organ of *amativeness*.

2. Philoprogenitiveness.

2. *Philoprogenitiveness*, or the love of progeny, the Στοργη of the Greeks, has its seat in those convolutions of the brain situated immediately above the hind part of the tentorium, and corresponding, therefore, on the outside of the skull with the crucial spine of the occiput. Dr Gall had observed a distinct protuberance on this part of the head in women, and comparing the skulls in his collection, found a similar elevation on the skulls of children, and on those of monkies. During five years he was in search of a faculty that was common to all the subjects of those observations, and was in the habit of suggesting this difficulty to his auditors: at length a clergyman who attended, observed that monkies have much attachment to their progeny. The Doctor pursued this idea, and found that it applied perfectly to the observed appearances, as the developement of this part coincided always with the energy of this propensity. In animals it is generally larger in the females than in the males of the same species. This rule holds good in the human subject, although it is liable to occasional exceptions; for there are men who manifest the strongest propensity to associate with children, and in whom we accordingly find this organ larger than in the generality of women. In negroes we find this organ more prominent than in Europeans. In the cuckoo, the crocodile, and other animals to whom nature has not appointed the office of rearing their progeny, this organ is extremely defective. The crime of infanticide is more likely to be perpetrated by mothers in whom this organ is deficient in size; and accordingly out of 29 women who were guilty of this crime, Dr Gall found 25 who had this organ extremely small. On the other hand, a female, who, being seized with delirium during child-birth, imagined that she was pregnant with five children, was found to have this organ unusually large.

3. Inhabitiveness.

3. The organ of *Inhabitiveness*, or the propensity which some animals, such as the chamois and the wild-goat, have to inhabit high situations, is placed still higher in the occiput than the former, in a line proceeding towards the top of the head. In animals of the same species which live in low countries, we do not meet with an equal degree of protuberance in this part of the brain, as is observable in those which prefer living in elevated and mountainous districts. This is seen even in the rat, some varieties of which choose for their dwelling corn-lofts or the higher parts of a house, while others prefer living in the cellars. This faculty is not very active in man; but Dr Gall conceived that it was in him allied to pride and haughtiness. Dr Spurzheim, however, disclaims this doctrine; as he thinks it impossible to confound the "instinct of physical height" with the moral sentiment of self love and pride.

4. Adhesiveness.

4. The organ of *Adhesiveness*, or the propensity to attach ourselves to persons, animals, or other objects, is situated on each side of the former, immediately under the *lambdoidal suture*, and gives a fulness to the lateral and posterior part of the head. This organ is the source of friendship, moral love, society, marriage, and attachment of all kinds. Dogs have it in an eminent degree; especially those races, whose fidelity and constancy are characteristic, as the terrier, spaniel, and lap-dog. It is less prominent in the butcher's dog, greyhound, and mastiff. It was very large in a notorious highwayman at Vienna, distinguished equally as a robber and a friend, and who chose rather to die, than to betray his confederates.

5. Combativeness.

5. *Combativeness*, or the propensity to fight, results from the operation of an organ, situated immediately behind the ears on each side, at a part corresponding to the posterior inferior angle of the parietal bone, and behind the mastoid process. It is the seat of anger as well as of pugnacity; and its locality is fully established, in Dr Gall's estimation, by an extensive series of facts. His first discovery of the seat of this faculty, was from his observation of the head of the Austrian General Wurmser; and it was subsequently confirmed by the experiments

Cranioscopy. we have already mentioned which he made on boys he had collected from the street. The breadth of the occiput is a criterion of the spirit and courage of horses, dogs, &c. The bull-dog and pug-dog are in this respect superior to the mastiff. The hyæna is strongly contrasted with the hare; and the guinea-hen with the robin red-breast.

6. Destructiveness. 6. *Destructiveness*, or the propensity to destroy in general, but more especially to destroy life, has its seat just above the ears; the prominence of which part will account for the strange pleasure which some people take in killing or tormenting animals, in seeing executions, and for their inclination to commit murder. Among animals, this instinct for blood is strongly marked in the carnivorous tribes, especially in the lion, tiger, and others of the feline tribe; and the breadth of their skulls in this part shows us the great size of this organ, compared with that of their victims, the sheep, the goat, or the hare. The heads of murderers have in general been found to possess a visible prominence at this place. When the band of ferocious robbers and assassins, who so long infested the left banks of the Rhine, under Schinderhanns, had been caught, and a number of them executed, Dr Gall found this organ strikingly developed in the heads of these banditti. This propensity is frequently strong in children, in idiots, and in madmen. Its object, in the lower animals, is evidently to procure the food on which nature destined they should live; yet some animals kill more than is necessary for their nourishment. In man this propensity presents different degrees of activity, from a mere indifference to the pain of animals, to the pleasure of seeing them killed or tortured, or even the most imperious desire to kill. Dr Gall called this faculty *murder;* but Dr Spurzheim thinks it produces the propensity to destroy in general, without determining the object to be destroyed, or the manner of destroying it. "It gives," says he, "the propensity to pinch, scratch, bite, cut, break, pierce, devastate, demolish, ravage, burn, massacre, strangle, butcher, suffocate, drown, kill, poison, murder, and assassinate."

7. Constructiveness. 7. *Constructiveness*, the propensity to build, or the disposition to the mechanical arts, is indicated by the developement of the brain at the temples. Dr Gall found this to be the case in great mechanicians, architects, sculptors, and designers; and also in the skulls of the beaver, marmot, field-mouse, and rabbit, which construct habitations. Hares, on the contrary, which lie in the fields, have this organ defective, although in general they resemble rabbits. He possesses the skull of a milliner of Vienna, who had a good taste, and understood perfectly the art of changing the forms of her merchandises, in this skull the organ in question is prominent. It is by means of this faculty that birds build nests, savages huts, and kings palaces. It produces also fortifications, ships, engines of war, manufactures of all kinds, furniture, clothes, toys, &c. There was a lady at Paris, who, every time she was pregnant, felt the greatest propensity to build. The excessive size of this organ may lead a man to ruin his family by building, or to coin false money.

8. Covetiveness. 8. *Covetiveness*, or the propensity to covet, gather and acquire, without determining the object to be acquired, or the manner of acquiring it, has its organ situated at the temples, on the anterior inferior angle of the parietal bone. This faculty gives a desire for all that pleases:—money, property, animals, servants, land, cattle, or any thing upon earth. It produces egotism and selfishness, and may, when abused, lead to usury, plagiarism, fraud, or theft. The instinct of stealing, it is asserted, is not always the effect of bad education, of poverty, idleness, or the want of religion and moral sentiment. This truth, says Dr Spurzheim, is so generally felt, that every one winks at a little theft committed by rich persons, who in other respects conduct themselves well.

9. The organ of *Secretiveness*, or the propensity to conceal, or to be clandestine in general, is situated in the middle of the side of the head, above the organ of the propensity to destroy. Dr Gall first observed this organ in a person who had many debts, but who had the address to conceal his real situation, so that the creditors could have no knowledge of each other. He ascribes to this faculty cunning, prudence, the *savoir faire*, the capacity of finding means necessary to succeed, hypocrisy, lies, intrigues, dissimulation, duplicity, falsehood; in poets, the talent of finding out interesting plots for romances and dramatic pieces; and finally, the quality of slyness in animals, as in the fox and the cat, who conceal their intentions, and are clever in hiding themselves. 9. Secretiveness.

To the second genus of the order of feelings, namely, Sentiments, belong the following faculties:

10. *Self-love*, or *self-esteem*. Dr Gall first noticed this organ, which lies in the middle of the upper posterior point of the head, in a beggar, who stated that he was reduced to his present condition by his pride, which made him neglect his business. The animals endowed with this organ are the turkey-cock, peacock, horse, &c. Dr Gall thought this organ is the same as that of the faculty which makes certain animals dwell upon mountains; but Dr Spurzheim, as we have already observed, draws a line of distinction between them. The too great activity of this faculty is the cause of various abuses, as pride, haughtiness, disdain, contempt, presumption, arrogance, and insolence. The want of it disposes to humility. 10. Self-Love.

11. *Love of Approbation*. Persons fond of the good opinion of others, have the upper posterior and lateral part of the head much developed. This may be called the organ of ambition or vanity, according to the object, which may be of various kinds. A coachman endowed with this faculty is pleased if his manner of conducting horses be approved; and a general is elated if he be applauded by his nation for leading his army to victory. This faculty is more active in women than in men, and even in certain nations more than in others. More women become mad from this cause than men. 11. Approbation.

12. Organ of *Cautiousness*. Two persons at Vienna were known to be remarkable for their extreme irresolution. One day, in a public place, Dr Gall stood behind them, and observed their heads. He found them extremely large on the upper posterior part of both sides of the head. Hence he derived the first idea of this organ. Circumspect animals 12. Cautiousness.

also, as the stag, roe, pole-cat, otter and mole, and those which place sentinels to warn them of approaching danger, as the chamois, cranes, starlings, and bustards, have this cerebral part much developed. This faculty produces precaution, doubts, demurs; and, in general, exclaims continually "*take care!*" It considers consequences, and produces all the hesitations expressed by *but*. When excessive, it produces uncertainty, irresolution, unquietness, anxiety, fear, melancholy, hypochondriasis, and suicide. Dr Gall finds this organ more strongly marked in children than in grown persons.

13. Benevolence. 13. The organ of *Benevolence* in man, or of *meekness* in animals, is situated on the superior middle part of the forehead. In most animals it is restrained to a passive goodness; but, in man, its sphere of activity is very considerable, producing all the social virtues, or, in one word, *Christian charity*.

14. Veneration. 14. The organ of *Veneration*, or of *Theosophy*, occupies the centre of the uppermost part of the *os frontis*. Dr Gall had observed in churches, that those who prayed with the greatest fervour were bald; and that their heads were much elevated. The pictures of saints show the very configuration which he had thus noticed in pious men; and the head of our Saviour, also, is generally represented of this shape. It is by this faculty that man adores God, or venerates saints, and persons and things deemed sacred.

15. Hope. 15. The organ of *Hope* is situated on the side of that of veneration. Dr Spurzheim considers the sentiment of hope as proper to man, and as a sentiment necessary in almost every situation; it gives hope in the present, as well as of a future life. In religion it is called faith; persons endowed with it in a higher degree are credulous.

16. Ideality. 16. *Ideality*, or the poetical disposition. The heads of great poets are enlarged above the temples in an arched direction. The sentiment inspired by this organ, is the opposite of circumspection; it renders us enthusiasts, while circumspection stops our career by saying "take care." If the part of the head above this organ, and a little backward from it, be very much developed, the person is disposed to have visions, to see ghosts, and to believe in astrology, magic, and sorcery.

17. Righteousness. 17. The faculty of *Righteousness*, which produces the sentiment of just and unjust, right and wrong, has its organ situated a little more forward than the organ of approbation. It produces the sentiment of duty, and constitutes what is called conscience or remorse. Dr Spurzheim admits farther an organ of *justice*, which he seeks for on the side of the following organ.

18. Determinateness. 18. *Determinateness.* Dr Gall observed that persons of a firm and constant character have the top of the brain much developed. Lavater had made the same observation. This faculty contributes to maintain the activity of the other faculties by giving constancy and perseverance. Its too great activity produces infatuation, stubbornness, obstinacy, and disobedience. Its deficiency engenders fickleness and inconstancy.

To the order called Intellect, and the first genus of that order, viz. the *knowing faculties*, belong the following species:

19. *Individuality*, or the faculty which procures us the knowledge of external beings, after we have received impressions from them by the external senses, occupies the middle of the lower part of the forehead; Dr Gall found this part very prominent, indicating a great developement of the anterior and inferior part of the brain, in all persons, who, from their extensive, but superficial knowledge in the arts and sciences, were capable of shining and taking a lead in conversation. It has been aptly, but satirically characterized as the *blue-stocking* faculty. Tame animals have the forehead more developed than wild ones, and are more or less tameable in proportion as the forehead is developed; Dr Gall, therefore, calls this organ that of *educability*. Dr Spurzheim, however, objects to this term, and has substituted that of individuality; he also remarks, that the organ is early developed in children, because they are obliged to acquire a knowledge of the external world. 19. Individuality.

20. The organ of *Form* leads us to take cognizance of the forms of objects, with the existence of which the preceding faculty had made us acquainted. Persons endowed with it in a high degree, have a great facility of distinguishing and recollecting persons; they are fond of seeing pictures, and if they make collections, they collect portraits. Crystallography is the result of this faculty. The conception of smoothness and roughness also belongs to it. This organ is placed in the internal angle of the orbit, and, if much developed, it pushes the eyeball toward the external angle, that is, a little outward and downward. The Chinese appear to have it in perfection. 20. Form.

21. *Size.* After the existence and figure of any body, the mind considers its dimensions or size, for there is an essential difference between the idea of size and that of form. The organ must therefore be different; it is probably, however, in the neighbourhood of the former. 21. Size.

22. *Weight.* The ideas of weight and resistance, density, softness and hardness, cannot be attributed to the sense of feeling, and require, therefore, a particular faculty for their conception. Its organ must be situated in the vicinity of the two last. 22. Weight.

23. *Colour.* The faculty of conceiving colour is, in like manner, totally distinct from the sense of vision, or the faculty of perceiving light. Its organ is placed in the midst of the arch of the eye-brows, giving them, when expanded, a vaulted and rounded arch. This configuration is characteristic of painters, and is strikingly displayed in the Chinese, who are well known to be very fond of colours. This faculty is generally more active in women than in men. 23. Colour.

24. *Space.* The faculty of local memory, by which we recollect localities, and find our way to places where we have been before, is much stronger in some persons than in others. Animals are also endowed with it, and it enables them to return to their dwellings and their progeny, when obliged to leave them in search of food. It is conspicuous in some dogs; while others are very deficient in this respect. 24. Space.

Cranioscopy. The migration of birds is the result of this faculty. The pictures and busts of great astronomers, navigators, and geographers, as of Newton, Cook, Columbus, &c., present a great developement of this organ, which is situated under, but extends a little beyond, the frontal sinuses. The swallow, the stork, and the carrier-pigeon, have all this organ. This faculty conceives the places occupied by the external bodies, and makes space not only known to us, but inspires a fondness for this kind of knowledge. It makes the traveller, geographer, and landscape-painter; it recollects localities, judges of symmetry, measures space and distance, and gives notions of perspective.

25. Order. 25. *Order*. This faculty enables us to conceive order. It gives method and order in arranging objects as they are physically related. Its organ is probably situated outward, but not far from the organs of size and space.

26. Time. 26. *Time*. Ideas of time are the result of a distinct faculty; for they may exist without those of order and number. They seem to be higher in the scale, and their organ, accordingly, occupies a higher place in the brain.

27. Number. 27. *Number*. All the ideas that are concerned about unity or plurality, that is, about number, belong to a faculty whose organ is situated in a part of the brain near the external angle of the orbit. The object of this faculty is calculation in general. When much developed the arch of the eye-brows is considerably depressed, or is elevated at the outer extremity. This conformation is apparent in the portraits and busts of great calculators, as Newton, Euler, Kaestner, Jedidiah Buxton, and Pitt. The heads of negroes are very narrow at this part; and, in general, they do not excel in this faculty.

28. Tune. 28. *Tune*. The perception of musical tone is distinct from that of sound, and implies a different faculty from that of hearing. Its organ is placed on the lateral parts of the forehead. Its form varies according to the direction and form of its convolutions. In Gluck and Haydn, it has a pyramidal form; in Mozart, Viotti, Zumsteg, Dusseck, and Crescentini, the external corners of the forehead are enlarged but rounded.

The heads and skulls of singing birds, especially the males, exhibit this organ fully developed. Monkeys are absolutely destitute of it.

29. Language. 29. *Language*. The organ of the faculty of learning the artificial signs for the operations of the mind, of perceiving their connection with the thing signified, and of remembering them, and judging of their relations, occupies a transverse situation in the midst of the knowing faculties, and presses upon the basis of the orbit of the eye, so as to project the eye forwards when much developed. This produces what is commonly called a goggle-eye, denoting strong verbal memory. Sometimes the eyes are not only prominent, but also depressed downward, so that the under eye-lid presents a sort of roll, or appears swollen. Such persons are fond of philology, that is, they like to study the spirit of different languages.

The second genus of the order Intellect, viz. the reflecting faculties, contains the following species:

30. *Comparison*. This faculty compares the sensations and ideas of all the other faculties; and points out their difference, analogy, similitude, or identity. Dr Gall observed various persons, who, in every conversation, had recourse to examples, similitudes, and analogies, in order to convince others; and seldom to reasoning and philosophical arguments. In them he found, in the midst of the superior part of the forehead, an elevation which presented the form of a reversed pyramid, and he named this organ, according to its functions, the organ of analogy. Nations who have this faculty in a high degree are fond of figurative language. 30. Comparison.

31. *Causality*. This faculty examines causes, considers the relations between cause and effect, and always prompts men to ask, *Why?* Persons fond of metaphysics have the superior part of the forehead much developed and prominent in a hemispherical form, as Mendelsohn, Kant, Fichte, and others. The ancient artists have given to Jupiter Capitolinus a forehead more prominent than to any other antique head. 31. Causality.

32. *Wit*. Persons who have this faculty, who write like Sterne, Voltaire, Piron, &c., have the superior external parts of the forehead elevated. The essence of this faculty consists in its peculiar manner of comparing, which always excites gaiety and laughter. Jest, raillery, mockery, ridicule, irony, &c. are its offsprings. 32. Wit.

33. *Imitation*. Persons who have a considerable elevation of a semiglobular form at the superior part of the forehead, have the faculty of imitating, with great precision, the gestures, voice, manners, and, in general, all the natural manifestations of men and animals. They have a disposition to be actors, and are prone to gesticulation. This organ is, in general, more developed in children than in adult persons. 33. Imitation.

Excepting in the case of idiots, all the thirty-three organs above described are possessed by every person, but they exist in greater or less perfection in different individuals. Peculiarity of character is the result of irregularity in the original structure, or inequality in the relative developement of the several organs; circumstances which, according as they are diversified, lay the foundation of every excellence, as well as constitute the fatal sources of vice and depravity. These doctrines should, however, by no means be understood as lending their sanction to the latter; for crimes are considered as flowing from the abuse of certain faculties, and as still requiring for their prevention the counteracting influence of morality, and the salutary coercion of law. It must be of importance to every individual to know, if such knowledge be attainable, what is the degree of energy of the propensities and other faculties with which he may have been naturally and originally endowed; because every organ and corresponding faculty may be invigorated by proper exercise. The business of education will accordingly consist in exciting or restraining their developement, according to their natural deficiency or exuberance. Cranioscopy, by pointing out what are the strongest faculties in a child, will enable us to adopt the best plan of intellectual, as well as moral discipline; will assist us in regulating his passions, and maintaining Application of the Doctrine.

a due balance between all his moral sentiments; and guide us in the choice of a profession for our pupil, conformable to the particular bent of his genius. "What benefit would arise to society," says Mr Forster, the zealous advocate of these doctrines, "should we be enabled to make a just election of objects in youth, to be placed in situations capable of ripening their naturally energetic faculties! Phrenology will lead to important considerations regarding criminal punishment, particularly in houses of correction. It will enable us to distinguish, not only between those who have naturally strong evil propensities, from those whom distress or other contingencies may have hurried on to crime, but will point out the particular nature of the evil propensities to be corrected." It will also tend, he conceives, to establish important distinctions between different kinds of insanity, and enable us to discover the treatment appropriate for the cure of each. Lastly, It may prepare the way to a radical improvement of the human race, by pointing out those conformations of the head which it is desirable to eradicate or to perpetuate, and which should therefore be avoided or preferred in the choice of marriages. "It is certainly a pity," says Dr Spurzheim, "that, in this respect, we take more care of the races of our sheep, pigs, dogs, and horses, than of our own offspring."

Objections to this System.

Such is the body of doctrines, and such the reasonings in their support, which have emanated from the school of Gall and Spurzheim, and which they have dignified with the appellation of a new science. A host of opponents, as might be expected, have arisen against a system so much at variance with common notions, leading to conclusions so remote from vulgar apprehension, and admitting so easily of being held up to ridicule by partial or exaggerated statements. We have already noticed the absurd objection founded upon its supposed tendency to favour materialism, and shall pass over others of a similar nature, which proceed upon the presumption of a greater knowledge of the laws of the creation than we really possess, or which are derived from imperfect or mistaken views of the theory itself. We shall also refrain from employing the weapons of ridicule against a system so vulnerable to its attacks, and which would have been so capable of affording Swift a new incident for the history of the philosophers of Laputa. The simple exposition of the sandy foundation on which it has been built, of the flimsy materials of which it has been composed, and the loose mode in which they have been put together, will suffice to enable our readers to form their own conclusions as to the soundness and solidity of the edifice.

No particular part of the Brain necessary.

It is, in the first place, obvious, that nothing like direct proof has been given that the presence of any particular part of the brain is essentially necessary to the carrying on of the operations of the mind. The truth is, that there is not a single part of the encephalon, which has not, in one case or other, been impaired, destroyed, or found defective, without any apparent change in the sensitive, intellectual or moral faculties. Haller has given us a copious collection of cases, which bear upon this point; and a similar catalogue has been made by Dr Ferriar, who, in a paper in the 4th volume of the *Manchester Transactions*, has selected many of Haller's cases, with considerable additions from other authors. The evidence afforded from this mass of facts, taken conjointly, is quite sufficient to overturn their fundamental proposition. This evidence is not impeached by the feeble attempts of Dr Spurzheim to evade its force, by a general and vague imputation of inaccuracy against the observers, or by having recourse to the principle of the duplicity of each of the cerebral organs; a principle of very dubious application, on a subject of so much uncertainty as the physiology of the brain. Poor, indeed, must be his resources, when we find him resorting to the following argument, in proof that the brain is the organ of thought, namely, that "every one feels that he thinks by means of his brain." We doubt much if any one has that feeling.

Analogical Arguments combated.

It requires, also, but a slight attention to perceive, that the very ground-work on which the whole of the subsequent reasoning proceeds, namely, that the different faculties of the mind are exercised respectively by different portions of the brain, is in no respect whatever established. The only arguments in its favour which bear the least plausibility, are derived solely from analogy. Now, analogy, in reasoning concerning the unknown operations of nature, is, at best, but slippery ground; and when unsupported by any other kind of evidence, cannot lead to certain knowledge; far less constitute the basis of an extensive system. The utility of analogical deductions as to what takes place in one department of nature, from our knowledge of what occurs in another, consists chiefly in their affording indications of what may possibly happen, and thus directing and stimulating our inquiries to the discovery of truth by the legitimate road of observation and experiment. But to assume the existence of any such analogy as equivalent to a positive proof, which can result only from the evidence of direct observation, is evidently a gross violation of logic. Yet it is upon assumptions of this kind that Drs Gall and Spurzheim have ventured to found all the leading propositions of their doctrine. In the secretions of the body, they observe, the preparation of different fluids is consigned to different glands, having different appropriate structures; and they consider this analogy as a demonstrative proof of what happens in the operations of thought, and the phenomena of the passions, which, because they differ as much in their nature as milk does from gall, must, accordingly, be the result of actions in different portions of the brain; which portions are, therefore, to be regarded as so many different organs, rather than as parts of one organ. Even in a case where all the analogies are favourable to one side of a question, such a loose mode of reasoning would be entitled to little confidence; but how fallacious must it not prove, when analogies can be pointed out which apply in opposite ways. It requires no extensive knowledge of the animal economy to perceive, that modifications of functions equally diversified with those of the intellect, are, in many cases, the result of actions tak-

 ing place in the same organ. Does not the same stomach digest very different and even opposite kinds of aliment? Yet we do not find that one portion of that organ is destined for the digestion of meat, and another for the digestion of vegetable matter; although the operations required for the conversion of such different ingredients into the same chyle, cannot possibly be the same. Nerves perform the double office of volition and sensation; but no anatomist has yet separated the different bundles of fibres which convey each impression, the one to the muscles, the other to the sensorium. The same organ serves for the hearing of acute and of grave sounds. The whole retina, and not merely different portions of its surface, receives the impression of different kinds of colour; there is not one organ for the perception of blue and another for the perception of red rays. Guided by such analogies as these, might we not be equally justified in concluding, that the same part of the brain may serve for the memory of words, as for the memory of things; and that the same portion of that organ which enables us to conceive the idea of figure, may also suggest to us that of size?

The same doctrine of the plurality of cerebral organs, is endeavoured to be supported by another analogy, equally vague and loose with the former, namely, that the sense of fatigue, from long continued muscular exertion, resembles, in its circumstances, the effects of long continued study on the mind, and is equally relieved, in both cases, by a change of action. To us, however, it appears, that this analogy might, with equal justice, have been adduced, as favouring the opposite view of the subject; for we can just as readily conceive the sense of fatigue to take place from the exercise of the whole organ in a particular mode, as from that of any part of the organ; and relief must equally, in both cases, be experienced from the ceasing of that action, or from the substitution of one of a different kind. The muscles admit only of one kind of action; and the energy which each derives from the nerves, when once exhausted, is not so readily replaced from the general stock belonging to the system. In the finer textures of the body, which approach more to that of the brain, the analogy not only fails of giving support to the doctrine, but has an opposite tendency. The same retina, when fatigued by the continued impression of a particular colour, is still as ready as before to receive the impression of another colour. The circumstance of partial fatigue with regard to one set of actions, may, therefore, exist, without implying the necessity of a separate organ for the performance of those actions. Indeed, if the brain have any laws similar to those of muscular motion, it must have a much greater number peculiar to itself, and all such distant analogies as those we have been considering, must be perfectly inconclusive. Similar observations will apply to the explanation of the phenomena of sleep, of dreams, of somnambulism, of partial losses of memory, and of insanity. It is equally conceivable, that they should result from the imperfect or differently modified actions of one organ, as from the separate activity of different parts of that organ, while the other parts are inactive. Analogies may be equally adduced in support of both sides of the question, and can certainly prove nothing on either.

Futility of anatomical proofs.

Drs Gall and Spurzheim appeal with great confidence to anatomy, and particularly to their own anatomical discoveries, as affording a solid support to their doctrines. "We never," say they, "separate anatomy from physiology, for physiology without anatomy is unfounded; while anatomy without physiology is useless. A physiological system of the brain would necessarily be false, were it in contradiction with its anatomical structure." This conclusion, which at best is but a negative one, is totally inapplicable to the theories in question. The anatomy of the brain is so complex, and so void of apparent adaptation to any purpose we can understand, that it will suit any physiological system nearly equally well; at least it can never be adduced in contradiction of any hypothesis, however wild, that can be framed as to the mutual operation of soul and body. All that these anatomists have done, in this respect, is to show that there is no appearance of a common centre of departure or of collection of nervous filaments. The separation of the parts of the brain and their diversity of shape, can no more be evidence of a diversity in their functions, than the multitude of distinct and separate lobules which compose the kidneys of birds, and of a great number of quadrupeds, are indications that each part performs a different office. Comparative anatomy, indeed, upon which so much is made to hinge, is of all guides the most fallible in questions of this nature, since we behold, in numberless instances, a great variety of ways in which nature accomplishes the same function and the same purpose, in different departments of the animal creation. But on a comparison of animals with each other, it may even be doubted, whether there is any connection or proportion observable between their intellect or inclinations and the number of parts in their brains.

The possibility of discovering the size and shape of the different parts of the brain from the external examination of the head, is also discountenanced by anatomy. There are often considerable impressions on the interior of the skull, where the corresponding exterior surface does not exhibit the slightest appearance of projection, and is sometimes even depressed; and there are frequently large prominences without, where there are no corresponding concavities within; so that when the outer surface of the bony case is compared with a mould in plaster or wax of the cavity itself, they exhibit considerable differences; and from the great variation which may take place in the thickness of the bones, this difference is not the same in degree in any two skulls.

Size of Organs no criterion of energy.

Hollow as are the foundations of this theory, the materials which compose the superstructure will prove, on examination, to be still more frail and unsound. The whole fabric rests upon the validity of a single proposition, which in itself is extremely questionable, namely, that the size of an organ is in general a criterion of the energy with which its function is performed. If any doubt should remain as to its truth, the whole of the pretended discoveries relative to the functions of the several parts of

Cranioscopy. the brain are shaken, and the fantastic edifice has no auxiliary prop to arrest its fall. So essentially, indeed, does the whole of this system depend upon the truth of a number of independent propositions, that if any one of them should turn out to be incorrect, the whole fabric must give way. The evidence in its favour, instead of being cumulative, is disjunctive. Where each proposition must be sustained by a separate series of proofs, as is the case here, it is evident that the chances of error must be multiplied in proportion to the number of steps we must ascend before we can arrive at the last conclusions. Let us, for example, examine the logic by which the above fundamental principle is deduced. "A large muscle," say they, "is stronger than a small one; and a large loadstone is more powerful in its attraction than a smaller one. Why should it not be the same with regard to the brain?" Thus again do they confide in a loose analogy, derived from another and a totally different part of the economy; and as if the organization and functions of the animal body were not sufficiently remote from the nature and operations of the human mind, the inanimate world is ransacked for the shadows of an analogy, which, although when viewed through such a distance of intervening mist, it may wear the semblance of reality, must immediately vanish on a near inspection. For the perfection of a refined and delicate instrument, such as must be that which is subservient to the operations of the intellect, innumerable conditions must concur; amongst which that of size, it is reasonable to suppose, is the least important. Delicacy of texture, fineness of organization, and harmony of adjustment between the several parts of its complex structure, must contribute infinitely more towards rendering it capable of performing its office, than superior magnitude; a circumstance which in itself is quite as likely to prove a source of imperfection, as to impart additional facility. Increase of size in the viscera of the body is more generally the indication of a diseased, than of a healthy state. Small eyes, Professor Hufeland observes, see with more strength, and last longer than large eyes. Why may not this be also the case with the organs of the brain? But really, in our present state of ignorance as to the mode of operation by which they are subservient to the processes of intellect and sensation, all such reasonings *à priori* on their functions, as connected with their size, must be completely illusory.

Practical difficulties. Even were we to admit so preposterous a doctrine as that the energies of the parts of the brain are proportional to their magnitude, insuperable difficulties would still be opposed to the determination of their relative size in the living head; crowded as all these organs are in a narrow compass, and completely hid from our view by an irregular bony case which protects them from injury, and which is itself covered by a thick and variable layer of muscle and integument. Let us, however, for the sake of argument, suppose that the form of each organ within the skull could really be ascertained by external examination of the head; shall we allow it to be an easy task to determine the real character of the individual who is the subject of observation? Are we always able to discriminate between real and affected sentiment; or to mark with certainty the operation of all the various motives which constitute the springs of action? Is the transient glance of a passing observer sufficient for unravelling the complex web of our affections, or unveiling the secret and tortuous recesses of the human heart, so as to assign to each principle its precise sphere of agency? Can the most profound moralist, or acute metaphysician, pronounce with confidence what are the natural dispositions of any human being, when these dispositions have been changed or modified, exalted or subdued, perverted or refined, by the force of habit, education, example, and a multitude of other powerful causes, which, in the course of life, have moulded his intellectual and moral constitution? Can he trace them through the guise of falsehood, artifice, and dissimulation, which so commonly hide his real character from the world, and which occasionally deceive the eye of the closest and most vigilant observer? Is it to the behaviour of a person who knows that he is watched; is it to the partial report of his friends; is it to the testimony of the individual himself, the most fallible of all, that the cranioscopist is to trust for his knowledge of human character? Such, however, is the kind of *experience*, from which it appears that all the doctrines relative to the functions of the different parts of the brain have been derived; and it is in this experience, as in an impregnable fortress, that the adherents of the system make their last and most resolute stand. Quitting the airy region of theory, they fancy themselves posted on a rock, secure against the insidious minings of scepticism, and bidding defiance to the rude assaults of argument. The appeal to the evidence of induction as the supreme authority in the court of philosophy, is made with confidence; and all the wild effusions of a bewildered fancy are presumed to be sanctioned by a supposed conformity with experience. You may speculate or reason, they exclaim, as you please; observation shows that such and such forms of the head, are the invariable concomitants of such and such predominant dispositions and faculties. Who will dare to set up his opinion in opposition to ascertained facts? We certainly pretend not to such boldness. We shall venture only to express doubts as to the reality of these facts, on which so much is made to depend; and to suggest the expediency, previously to any admission of their truth, of inquiring not only into the manner in which the knowledge of these pretended facts has been obtained, and in which inductions from them have been made, but also into the talents and qualifications of the observer on whose testimony we receive them. We should know in what spirit he conducted the inquiry; with what previous dispositions he examined the objects of his contemplation; what motives led him to these researches; and what interest he may have in the event. Experience, we should recollect, leads to very different results, according to the sagacity and good faith of the person who acquires it. Minds already prejudiced collect from it only a confirmation of their errors, and become, by its means, only the more obstinately wedded to their opinions. The sailor, steadfast in his belief that his whistling

to the sea will raise a wind, or conjure up a storm, instead of being undeceived by experience, is only the more strengthened in his faith by the observations which it furnishes to him. In what a multitude of instances do we not find men deceiving themselves as grossly, when they draw inferences from what they see, if prepossessed with the expectation of meeting with a certain coincidence, or succession of events! How disposed are we all to disregard the exceptions to a preconceived rule, and to allow undue weight to every example that conforms to it. How willingly we repel the evidence that opposes, and how eagerly we catch at whatever corroborates our previous notions, especially when those notions have originated with ourselves, and are viewed as the darling offsprings of our own lucubrations.

Nature of the Logic employed.

The discerning reader may already have perceived strong indications of this bias in the framers of the system of cranioscopy, from the account we have already given of its origin and history, and of the kind of evidence on which they pretend to establish its doctrines. In order, however, to enable him to form a correct idea of the species of logic which they are in the habit of employing, and which they deem conclusive, and of the tone of mind with which they prosecute the investigation of subjects where nothing but the exercise of consummate prudence can secure us from error, we shall conclude by offering one or two specimens of their mode of reasoning. We shall pass over the numerous stories, each more ridiculous than the preceding, of irresistible natural inclinations to wander from place to place, to commit murder, theft, infanticide, and other crimes, without any assignable object. We shall refrain from criticising the wonderful accounts of people who were insane on one side of the head only, and observed their insanity with the other side; and of others who heard angels sing, and devils roar, only on one side; nor stop to investigate the curious case of the woman who declared in a court of justice, when accused of having destroyed her infant, that her sole motive for becoming pregnant was that she might enjoy the exquisite pleasure of killing her child. Neither shall we venture to involve ourselves in that metaphysical labyrinth of the *thirty-three special faculties* into which they have analyzed the human soul; but content ourselves with examining, what in fact alone deserves examination, the sort of evidence brought forward to establish the relation between each faculty and a particular defined portion of the brain. We shall take, for this purpose, the following passage, which may be esteemed a fair specimen of the whole.

"Gall examined the head of a woman at Vienna who was known as a model of friendship. She suffered different changes of fortune; she became alternately rich and poor; but was attached to her former friends. Gall found the part of her head situated upward and outward from the organ of philoprogenitiveness, very prominent, and called it the organ of friendship. Our observations are not multiplied enough to enable us to decide positively on this organ; yet its seat appears to be more than probable. It *must* be inferiorly, because this faculty exists in the lower animals, and is a propensity. *For this reason* it belongs to their region of the head; and according to its mimical signs, and the motions of the head when it is active, it lies laterally and backward." Dr Spurzheim, it is obvious, here reasons completely in a circle: for he assumes as true the thing to be proved, namely, that faculties of a certain class reside in a certain department of the head, and then applies it to establish the very proof on which the proposition itself ought to have rested. In order to render intelligible the latter part of his argument, the reader should be informed that Drs Gall and Spurzheim believe, that, when any faculty of the mind is strongly excited, the action of the corresponding organ in the brain tends to raise that part of the head in which it is situated: so that the person has a propensity to lay his finger upon the nearest external part of the head; or sometimes to apply his hand to it, either to cool it when too hot, or to warm it when too cold: and that he is occasionally prompted to rub it in order to excite it when too sluggish. Thus, when we endeavour to recollect a name or a word, we unconsciously slap our foreheads, or rub the skin a little above the eyes, or perhaps higher still, just where the appropriate organ of memory is situated, that it may awake and exercise its peculiar faculty. When embarrassed by any difficulty, we gently stimulate, in like manner, the organ of contrivance, by scratching the head at the part under which is the seat of *constructiveness.* The timid man scratches his head on the organ of courage behind his ear, as if he tried to rouse the feeble organ into activity. A proud man holds his head erect upon his shoulders, and raises himself upon his toes, for no other reason than because the organ of the sentiment lies at the very top of the head, and is therefore elevated by the action. A sense of danger, or the necessity of *circumspection*, leads all animals, man not excepted, to stretch their necks forwards horizontally, thus presenting the broad extent of that organ, as it were in front. Devotion raises the head gently; and our adorations are all directed upwards, not because we regard the Deity as above, but because the organ of adoration is situated in the centre of the upper part of the head. When busied in deep contemplation, we cover the whole forehead with our hands, as it is there that the reflecting faculties are lodged: and, accordingly, when we reproach any one for his want of reflection, we put our hand to this part of the head; and exclaim, "he wants it here." If we try to recollect a date, we put into action the organ of time, which being situated over the eyebrows, and a little to one side, occasions an involuntary movement of the eyes upwards and towards the temples. In beating time to a musical air, we make the head oscillate from side to side, because the organs of tone as well as of time, being situated on each side, and being alternately in action, occasion these gesticulations. Sterne excelled in wit: and we find him represented in all his portraits with his head leaning on his hand, the fore-finger of which is placed on a particular part of the forehead. Dr Spurzheim considers this as one of the proofs that the organ of wit occupies that very spot.

With minds capable of allowing any weight to such observations, and imbued with such notions

of the nature of philosophical induction, as are implied by the grave admission of such frivolous arguments as these, the investigation of the laws of nature must be an easy and delightful task. With the abundant and all powerful resources, which their indulgent method of reasoning is ever ready to supply, all difficulties may be smoothed away, all chasms immediately filled up, and all obstacles made to vanish the moment they arise. We need be under no embarrassment at meeting with a skull exhibiting a particular prominence, although the faculty which should correspond to it be deficient. Doubtless the individual must have been strongly gifted by nature with this faculty, but education has long ago taught him to disguise or suppress its manifestations: it exists, perhaps, unknown to the person himself, and wants only a proper occasion for its being exhibited: or more probably the other faculties, having received a greater proportional developement, have overpowered and prevented it from appearing. If we find, on the contrary, a strongly marked faculty, without the corresponding shape of the head, we may still conclude that the organ exists notwithstanding; for the neighbouring organs, having received a greater extension, may have pushed it from its true place, or have grown up around it, and have concealed it from vulgar observation. Its not having been recognized is only a proof of want of skill in the observer; no doubt, it would easily have been discovered by the eye or hand of a true believer, and experienced cranioscopist: for it should be recollected that the differences are often very minute, and require the *tactus eruditus* for their detection. Besides, how can we be certain that the excellence of the faculty in question is not of an artificial or relative nature. and that it results from education, or the weakness of opposite faculties, rather than from nature? If all these expedients should fail us, we have nothing to do but to plunge into the depths of metaphysics, to refine, and make subtle distinctions, or loosen the signification of a few words, till we have entangled ourselves in a wood, and lost sight of the real difficulty that had perplexed us. Thus will the theory be freed from any exception, and the induction be rendered complete. With such a convenient logic, and accommodating principles of philosophizing, it would be easy to prove any thing. We suspect, however, that on that very account, they will be rejected as having proved nothing. (W.)

CRAWFORD (Dr Adair), a physician distinguished by his researches in chemical physiology, was born in Ireland, about the year 1748. His father, the Rev. Thomas Crawford, was the Presbyterian minister of Crumlin, near Belfast, in the county of Antrim. The family were originally from Scotland: a remote ancestor, who was a clergyman, having fled from thence to Ireland, during the reign of Charles II. in order to escape the fury of religious persecution directed against all who like himself had refused to conform. The zeal which had stood so severe a test, appears to have been cherished and perpetuated as an honourable inheritance in the family, which exhibited for six generations the clerical profession descending from father to son. Adair Crawford was, from his early youth, remarkable for the sweetness of his temper, the excellence of his heart, and the strength of his understanding; qualities which were so happily united, as at once to engage the affections, and to command the respect of all who knew him. To his nearest relatives he was an object of extraordinary interest, from the delicacy of his constitution, which required that he should be brought up with peculiar care: but so amiable was his disposition, that no shade of jealousy was ever excited among his brothers and sisters by the greater attention that was paid to him. He received his classical education from his father; and at the age of 14 was sent to Glasgow for the prosecution of his studies. Distinguished from a child by a thirst for knowledge, his progress at the university was rapid, and corresponded with the warmest hopes of his parents. They had intended him for the vocation of a Presbyterian clergyman, which was also the destination of his eldest brother; and he at one time bestowed much pains in the composition of sermons with that view; but he afterwards relinquished the plan on account of the weakness of his voice. It was then proposed to him to pursue the profession of the law, for succeeding in which he was eminently qualified by the excellence of his memory, and the acuteness of his reasoning powers; though the same physical incapacity as to exertions in public speaking might, in a great measure, confine his practice to that of a chamber lawyer. He accordingly turned his attention to this new course of studies, which he pursued under the guidance of the celebrated Dr Millar of Glasgow. At this period, his younger brother Alexander was a student of medicine in the college of Edinburgh, and was sufficiently advanced in the knowledge of his profession, to discover the immensity of the field which this science lays open to an ardent mind, and the scope which it affords for the exertion of industry and genius, such as he knew his brother possessed. Convinced that extraordinary success would be the result of this new application of his powers, he persuaded him once more to change his views, and while they were together at their father's house, he one day left him, on setting out on a journey, a skull and a few other dry bones, together with Monro's book on *Osteology*. On his return, he found, as he had expected, that Adair had already outstript his preceptor in accurate knowledge of the subject. It was then decided that he should return to Glasgow on the ensuing winter, for the purpose of attending the medical classes. This plan he carried into execution with great steadiness: and as early as the following spring, had begun to direct his inquiries to the connection between respiration and animal heat; a subject which, for a long time, engaged a principal share of his attention. In the next winter he went to Edinburgh, still pursuing the same objects of study at that university. His views of the

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theory of animal heat were very favourably received by the professors, and were long taught by Dr Monro in his anatomical lectures. In the ensuing spring, 1779, he went to London, where he then published the first edition of the work which has gained him so much celebrity. In the beginning of the same winter, a degree, probably an honorary one, of Doctor of Physic was conferred upon him by the university of Glasgow. He was held in much respect by the professors of that college; his long residence among whom had given them the means of appreciating his worth and talents. It was observed by the celebrated Dr Reid on his quitting them, that he had left no man behind him better qualified for the professorships of Greek and of Natural Philosophy than Adair Crawford. The facility with which he acquired knowledge of every kind was, indeed, extraordinary, and appeared to be the result of the singular faculty he possessed, of concentrating the whole force of his mind upon any subject to which he chose to direct his attention. He now determined upon settling in London, and soon after offered himself as candidate for one of the dispensaries, to which, after a severe contest, he succeeded in being elected physician. His talents speedily brought him forward in the philosophical world, as well as in his own profession. He was elected a member of the Royal Society: and shortly after he obtained the appointment of physician to St Thomas's Hospital. In the year 1788 he published a second edition of his work, greatly corrected and improved, under the title of "*Experiments and Observations on Animal Heat, and the Inflammation of combustible Bodies, being an attempt to resolve these phenomena into a general Law of Nature.*" His reputation as a philosopher was now established, and procured him the notice of all the scientific noblemen of the kingdom, and the appointment of lecturer on chemistry to the academy of Woolwich. Being led from speculation to suppose that barytes might prove an efficacious article of the materia medica, he made several experiments on the effects of the muriated solution upon himself, principally with a view of determining the dose that might be taken with safety. He then applied the remedy to some bad cases of scrofula at St Thomas's Hospital, with a degree of success that raised in his mind the most sanguine expectations of its proving a specific for the cure of that untractable disease: expectations which, as has happened to so many new remedies, subsequent experience has far from realized.

Dr Crawford was now rising into great eminence as a medical practitioner; but his incessant application to the laborious duties of his profession, as well as to his philosophical pursuits, was beginning to undermine a constitution naturally weak. He was invited by the first Marquis of Lansdowne to his seat of Hardwell Cliff, near Lymington, in hopes that the change of air might have a beneficial effect upon his health. But the foundations of his disorder were too deeply laid; he gradually declined, and shortly after died at Lymington, on the 29th of July 1795. He was buried in the church at Hardwell. It was the intention of his noble patron to have erected a monument to his memory, and, at his Lordship's solicitation, two very appropriate and elegant compositions were written, the one by Dr Denman, who was among his early friends, and the other by the well-known Gilbert Wakefield. Lord Lansdowne, however, did not live to see his design carried into execution.

Crawford.

During the year 1785, he married Miss Stone, a lady from Devonshire, by whom he left four children, two sons and two daughters, still living; the eldest son a clergyman, the other in the medical profession. The daughters, who were infants at his death, were principally educated under the immediate superintendence of the celebrated Miss Elizabeth Hamilton, who was first cousin to their father, and who adopted them as her own children.

His eldest brother, the Reverend William Crawford, and the father of Dr Stewart Crawford of Bath, was a man of considerable literary attainments; he published *Remarks on Lord Chesterfield's Letters*, which met with much success, and also *Translations from Turretine*, and a short *History of Ireland*. His second brother, John, was for many years a surgeon in the service of the East India Company, and published, nearly fifty years ago, a pamphlet showing, from a number of cases, the efficacy of calomel, conjoined with other purgatives, in the treatment of those morbid affections of the liver to which the inhabitants of India are so prone; a work which probably laid the first foundations of the practice which has since been so generally adopted. His brother Alexander, whom we have already had occasion to mention, is a physician at Lisburn in Ireland, and has obligingly furnished us with most of the particulars above given, relative to his brother, who was endeared to him by the strongest ties of affection, and of whose moral worth he speaks in terms of the highest veneration.

The published works of Dr Crawford, besides that on *Animal Heat*, above noticed, were a paper in the *Philosophical Transactions*, "*On the power inherent in the Human Constitution of resisting high degrees of Temperature;*" and another "*On the effect of Muriate of Barytes in the Cure of certain Diseases.*" A posthumous work of his "*On the effect of Tonics on the Animal Fibre,*" was edited by his brother, Dr Alexander Crawford.

He had a taste for poetry, which, however, he indulged but sparingly. An elegy which he wrote on *the death of Lady Sarah Stewart*, the mother of the present Lord Castlereagh, was supposed to have considerable merit, but he could never be prevailed on to publish it.

The following is the epitaph written for his intended monument, by Gilbert Wakefield.

Beneath this Pillar
are deposited the remains of
ADAIR CRAWFORD, of London, M.D. F.R.S.
who died the 29th of July 1795, aged 47:
distinguished as a Philosopher and Physician,
by talents and attainments that have rarely been equalled;
admired and beloved as a man,
for guileless simplicity of heart,
and lofty elevation of sentiment;
for a noble ardour in the cause of truth,
rendered more impressive by natural gentleness of disposition;
for unaffected deference to the worth of others,

and a modest estimation of himself;
for diligence and success in scientific research,
and for firm adherence to religious principle.
In respect to his memory,
WILLIAM
MARQUIS OF LANSDOWNE
hath caused this monument to be erected. (W.)

CREDIT, in the sense in which we are now to treat of it, is the trust which is given to a person when he obtains a loan of money, or purchases any article, the payment of which is to be made at an after period. Every sum of credit, therefore, must be founded on a transfer of a corresponding sum of capital; and the whole amount of credit existing at any time, can never exceed that of the lent capital. Credit is, in reference to the person who gives it, the power of lending, and to him who receives it, the power of borrowing. The basis of credit is confidence, and this is found to exist extensively, only where good faith and punctuality have been allowed to grow into habit, and where laws afford to creditors the easy and certain means of recovering their debts.

In young countries, before dealings have become multiplied, we find people inattentive to their money engagements, when there is no want of property with the debtor, and even when the payment of the debt has been fixed by document to a positive term. But as transactions increase, and population presses more closely together, a knowledge of the circumstances of individuals is rendered difficult, and a necessity for punctuality arises, to prevent doubts being entertained of the ability to pay. And this apprehension of discredit entertained by the debtor, and of its consequences to his future transactions, has more effect to establish and maintain good faith and exactness, than the operation of the laws is able to produce.

Nature of Credit.

When capital is abundant, relatively to the means of employing it, the competition of capitalists produces a facility of obtaining credit; and parties become enabled to borrow, and purchase upon credit, who could not do so before. Credit is then said to be high, but it is the value of the capital, which from the overstock has become low. The capitalist, in these circumstances, grows less scrupulous about his security, that he may bring within the range of his dealings a greater body of borrowers or purchasers, and thereby be enabled to keep up his price.

When the supply of capital continues in this state for any length of time, it gives rise to an imprudence of conduct which lays the foundation of much after evil. Sales and loans are made at credits far beyond the ordinary periods; and those into whose hands the extra capital by this means passes, considering it as a fund with which they may trade, go on also extending their dealings and credits, until the whole system is put upon the stretch. In this situation any interruption to the sale of commodities occasions instant confusion and distress. The confidence which had prevailed, gives place to alarm and distrust, and the same effect is produced for the time, by the retardment of the circulation, that would have been experienced had the capital itself been withdrawn.

By the operation of credit, not only is the circulation of capital facilitated, and its employment increased; but, by its means alone, certain descriptions of capital can be brought into action.

When an article is sold upon credit, the seller places, for the time, a portion of his capital at the command of a party who may have no capital of his own. This person, nevertheless, by another operation of credit, is enabled to sell upon credit also, and still keep his engagement with the party from whom he bought. This he accomplishes by calling in the assistance of the money capitalist, the banker, who advances to him the amount of the sale, upon his and his purchaser's joint security, and receives in consideration a rent for the sum advanced. By this process facility and extension are given to circulation, beyond what could take place if the commodity could be exchanged only for immediate value; while an opportunity is, at the same time, afforded of employing a branch of capital which would otherwise remain inactive and without use.

It is almost unnecessary to remark, that it is by the operation of credit, that a return is got from the capital of persons who are incapable of employing it themselves, and which can be put into a state of useful activity only by lending it to others.

Even the fixed capital, when leased to a tenant, may be said to be put into circulation by credit. For when a landholder lets a farm, suppose of the value of L. 10,000, at the rent of L. 400 a year, he lends the tenant L. 10,000 of capital, as much as if he lent him the money, and enabled him to acquire for the time the property upon which he is to operate.

Company Credit.

In Scotland, after the disposition to commercial pursuits began to manifest itself, the progress was retarded, by the total want of commercial capital in the country. To get the better of this difficulty, and draw to these employments any little capital that otherwise existed, it became the practice, when a commercial undertaking was to be entered upon, to associate in the adventure some persons of known substance, and upon the joint credit of the parties forming the company, to borrow the capital necessary for carrying it on. The credit which was thus established is called Company Credit, and is effectual to its proposed end, of borrowing or purchasing with advantage, according to the supposed responsibility of the parties of whom the company is composed.

Up to the year 1793, a considerable proportion of the manufacturing and mercantile concerns of Scotland were carried on upon this plan; and to give strength to their credit, and encourage those who had money to lend, to place it with them, a rule was established, and confirmed by decisions of the Courts of Law, that, in case of bankruptcy, a creditor of a company should be entitled to claim upon each of the partners' separate estates, in competition with the party's individual creditors, for the balance of his debt, unpaid from the company's effects.

Circulation of Credit.

When a party purchasing or borrowing capital, gives a written obligation for the amount, payable to the order of his creditor, at a certain fixed period, he embodies a sum of credit capable of being ex-

changed again for capital; and the transference of these documents to new parties, who replace to the former creditor the capital he had lent upon them, is what is called a Circulation of Credit. Indeed, without the use of bills, or of some instrument of similar powers, credit must have been confined to a single operation between first contracting parties, and the circulation of capital limited to what could have been effected in this way. But a transferable document of the sum to be received, becomes itself a negotiable or marketable article; and the collective credit of the parties, through whose hands it may successively pass, continuing to be engrafted upon it, a new facility is gained to circulation by every movement which it makes.

The whole of the credit embodied by bills, however, is not brought into circulation; a part only of the sellers or lenders, requiring to have their capital replaced to them by anticipation. But it is according to the expected facility with which payments may be thus anticipated, that credit is at first freely and readily given; and whenever any thing occurs to impede the circulation of credit, there is an immediate disposition in the merchant to withhold or limit it.

Every transfer of capital, made upon a buyer or borrower's own obligation of payment, creates a new sum of transferable credit; and this is the case, although it should be the same capital that is again and again transferred. But a sale of goods, or an advance of money upon the obligation of a third party, indorsed to the seller or lender, forms no addition to the sum of circulating credit, the transaction being the circulation, not the creation, of a sum of credit. Neither does a succession of purchases or borrowings effected by means of the same document indorsed from the one party to the other, add to the sum of credit in circulation. For although each of these transactions is the ground of a separate obligation between the parties contracting, there is with the whole but one absolute creditor, the holder of the bill, and one absolute debtor, the acceptor of the bill; the others being merely contingent debtors to the one, and contingent creditors of the other.

Circulated credit is to be classed into that circulated by loan, and that which is circulated by means of sale. The first is the circulation of the credit founded upon the obligation of individuals or private companies, and called private credit; the second of that founded upon the obligations of the state, or the transfers of the stock of corporate bodies, and called public credit.

The documents of these two descriptions of credit possess different and distinct qualities, and are differently negotiable. It may be proper, therefore, to examine how they are employed as means of borrowing or purchasing; what are their separate powers; and what is the probable extent of the circulation of each.

We shall begin with those belonging to private credit, which are as follows:

Circulation of Private Credit.

First, Obligations payable to the bearer on demand, and which, being passed without recourse, are employed as money.

Second, Transferable obligations payable at an after date, as notes of hand and bills of exchange, which, being negotiated with recourse upon the preceding obligants, are taken as guaranteed pledges of a sum to be received when they become due.

The circulation of obligations, payable to the bearer on demand, or notes employed as money, is the circulation of a credit borrowed by the issuer of the note from the public; the holder of the note at the time is the creditor; and the property he gave in exchange for it, is a loan from him to the banker.

As it is in the power of the party giving this credit, at any time to put an end to it, by calling for his money, these notes circulate upon the credit of the issuer alone. No assurance of payment is required from the person from whom they are received, as is the case with bills: the payment of which, being at a future date, it is thought necessary to reserve recourse against the parties through whose hands they have passed. The circulation of notes payable on demand is, therefore, a circulation of what may be termed single credit, and bills a circulation of collective credit.

When bank notes are issued by a banker, in discount of a bill, it may be supposed that a twofold credit is put into circulation; a credit to the party to whom the bill has been discounted, and a counter credit from him to the issuer of the notes. But in this stage of the transaction, no circulation of credit has taken place. Credit is circulated only when exchanged for capital, and in this case it has been but the exchange of one credit for another. The banker, indeed, in giving his notes, payable on demand, in exchange for a bill payable at a future date, gives what is of a quality different from that which he receives. For, what he gives is immediately exchangeable for capital, and to the person receiving it is the same as capital. But still it is only credit he has parted with, which will not be in a state of circulation until it comes to be exchanged for capital. In as far as relates to circulation, the transaction is the same with that of a person lending his credit to another, by accepting a bill to him without value. A sum of credit is thereby created, but is not circulated until the bill comes to be exchanged for value.

The credit that is in circulation from the exchange of bank notes for a bill, is a credit from the party who at the time has given capital or value for the notes. When the banker "cashes" them he becomes the creditor, but while they remain in circulation the public is the creditor.

The amount of credit, from the circulation of cash notes, never can be pushed beyond what would have been the value of the specie that would have been in circulation, had the currency been of the precious metals, which the notes only serve to represent. Should the notes cease to be convertible into specie, their amount, indeed, may be augmented at the pleasure of the issuer; but their value, and the credit in circulation from them, will still be regulated by this limit. The increased sum will represent the value which the smaller did before, and each note will be reduced in its value, in the proportion

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of the increase that may have taken place of the whole.

This description of circulating credit is of a quality different from the others. From supplying the place of capital, in its character of currency, it is lent out as capital; but loans from this fund are precarious: its amount depending upon the state of public confidence, and liable to be diminished by every call upon the banks to replace the notes with specie.

Circulating notes, not convertible into specie, issued under the authority of the State, have been called a fabric of unreal credit. But this currency, however unsuitable to its proper ends, affords a circulation of real credit. It is, indeed, exposed to constant fluctuation of value, according to the amount of it in the circle, and the party taking it is obliged, for his own safety, to include in the price of what he gives for it, sufficient to cover the difference between it and specie, and the risk of fàrther depreciation while it may remain in his hands. Still, however, an amount of credit, to the value of what has been given for the notes, in the first instance, is put into circulation, and an amount continued in circulation, to the value always of what they are exchangeable for at the time; the holders of them always remaining creditors of the issuer, to the extent of the whole sum which the notes profess to pay.

A currency of this description, however, is inapplicable as a measure of value, and therefore unfit to be employed as a circulating medium. And as to the other object, intended by its issuers to supply an amount of funds to the state; the depreciation with which it must be issued at first, and the loss to be sustained from taking it back again at par, render it an expensive means of borrowing.

With regard to obligations payable at a future date, which constitutes the second branch of private credit, and which we are next to consider, the credit founded on them is circulated, either in the transfers of the ordinary capital, in sales, as, when the credit of indorsed bills is employed to purchase goods; or, in the transfers of the banking capital, in loans; as when the credit of indorsed bills is employed to borrow money; the transfer under the latter, when the bill is exchanged for money, being often a farther circulation of a credit previously circulated under the former, when the bill was exchanged for goods.

A fictitious bill, that is, an acceptance given without value, vests in the person in whose favour it is drawn, a sum of transferable credit not less than would have been the case, if it had been the document of a sale, or loan of property. Mr Thornton, in his treatise, established the doctrine, till then disputed, that the credit of a bill does not rest upon the nature of the transaction in which it has originated, but upon the conceived ability of the obligants to discharge the debt.

There are no means of estimating accurately what is the amount of bill credit in circulation in the country; but from some data, furnished in the discussions which took place on the bullion question, the sum must be very great. It was stated by Mr Richardson, before the Committee of the House of Commons, that the bills and drafts daily paid in London amounted upon an average to L. 4,700,000. They have since been stated as high as five millions. Now, supposing that three millions five hundred thousand pounds of this sum belong to bills, and this proportion will not be thought too great, when it is considered that the bills are all accepted, payable at the office of a banker, and require no draft on him to discharge them: and supposing that these bills, on an average, are of two months date, and striking off thirteen days, for Sundays and holidays to fall within the period, the current sum of paper, payable in London, cannot at any time be of less amount than one hundred and seventy-five millions Sterling.

The whole of the credit established by these bills, however, is not in circulation. That belonging to bills which are in the bankers' hands, in security of bills accepted by them to their correspondents, is to be deducted from the sum, as credit exchanged. It is only those bills which have been discounted, or those for which capital has been given in exchange, that are to be included in the sum which makes up the bill credit in circulation.

There are no data from which to form a calculation of the bill circulation of the rest of the kingdom; but as a great proportion of the dealings of the country of England are transacted with London paper, the amount of bills payable in the country, including Scotland, must be greatly below that stated for the payments of London. It might perhaps be too high to rate it even at a fifth of that sum.

The being able to embody in bills every sum of credit, has furnished the means of employing, with incalculable advantage to commerce, a portion of the capital of the country, which otherwise, it is probable, would have remained inactive.

The security they afford of the repayment at a stipulated period of the sums lent upon them, furnishes the means of an interim employment of money held for after occasions, which the party would not otherwise venture to lend out; of money which formerly lay idle in the hands of parties unacquainted with any safe means of using it; and of the money which traders are daily receiving in the course of their business, but which they do not immediately require. These different sums collected in the hands of a banker, form what is called the banking capital of the country; and which, lent out upon these securities, produces not only a profit to him, but interest to the parties who have placed them at his disposal. The importance of this intermediary fund in the transactions of the country is such, that when from distrust, at any time, these deposits are withheld or withdrawn from the bankers, the mercantile body is convulsed throughout.

Circulation of Public Credit.

We now come to the second division of credit, that circulated by sale; the documents of the first branch of which are, the negotiable obligations of government, as Exchequer Bills, Navy Bills, &c. and the whole of the public funds, constituting what is termed the Credit of the State.

When capital is to be competed for, this credit has an advantage in the market over the former. Its price rises according to the demand, and by

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that means it is enabled to secure whatever share it may require of the supply. This is not the case with the credit circulated by transfers of capital upon loan; the price, or stipulated rent of which, cannot, whatever may be the demand, rise beyond a prescribed limit. It has the effect, in these circumstances, to force the capital applicable to this part of the circulation to seek the employment of the other; so that the inconveniency produced by an interruption to circulation, from a diminution of the general capital, falls entirely upon the circulation of bill credit, the supply for the circulation of the credit transferable by sale being kept full, at the expence of that applicable to the circulation of credit transferable by loan.

In consequence, all additions made to the national debt have an effect to operate against the circulation of the credit founded upon bills; for every new loan not only takes a large sum permanently from the fund of circulation, but adds a proportion of the newly contracted debt to the sum to be circulated; the consequence of which is a fall in the market value of these securities, according to the change which has taken place upon the two funds. But this diminution of the means of circulation does not interrupt the circulation of government obligations, which continue to command a supply of capital, by accommodating their price to the state of the market under every pressure of circumstances. But when they happen to be in this state, their circulation enters into competition with government itself in its biddings for capital for new loans. For the price they bear at the time fixes the terms upon which the minister is enabled to make his bargain with the money lenders.

When government goes on for a length of time in a course of borrowing, there is a progressive depreciation of the value of these securities, in the exact degree in which the loans take from the amount of the circulating capital, and add to the sum of credit to be circulated. This was strongly evinced in the fall of the price of stocks in the early period of the war of 1793, notwithstanding the influence at the time of an unprecedented accession of new capital, proceeding from the greatest flow of commercial prosperity which the country had ever experienced.

The transferable shares of public stock companies, from being occasionally a means of temporary investment of capital, have by some been considered as forming a part of the circulating credit of the country. This is not the case. The stocks of these companies form a part of the ordinary circulating capital; of consequence, the transfers of their shares are not operations of credit, but exchanges of capital between the buying and selling parties. The transfers of the premiums, however, paid in the purchase of this description of stock, which, although no part of the capital, form an immediate part of the price, may be fairly considered a circulation of credit, and to be added to the amount of the circulating credit of the country. The mode of circulating this credit being the same with that of the public funds, and its market value rising or falling with the general abundance or scarcity of capital, its circulation, when capital is scarce, immediately interferes with the circulation of credit by simple borrowing.

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We have now examined what credit is in its simple state; what is meant by a circulation of credit; and what are the means by which credit is circulated; and it appears, that credit, whether in a simple state, or in a state of circulation, proceeds from capital lent, and never can exist, or be circulated, to any extent, but by means of, and in conjunction with capital. That there is no such thing as an unreal fabric of credit; for wherever we find credit existing, we may rest assured, that there exists with it a corresponding amount of capital. That credit being indispensable to the circulation and proper distribution of capital, its amount will always correspond to the amount of the capital to be circulated. That the danger, supposed to arise from credit, is not in the extent, but in the disposal of it—not in the sum of it created or circulated; for the accumulated capital must and will seek employment in this way; but in the imprudence with which the loans constituting it may be made, allowing the capital to get into hands that cannot replace it. That credit, in its operation, is to be checked only by distrust, arresting for the time the circulation of capital; but that this interruption to credit never can be but of momentary duration; for the desire to keep capital in a productive state will quickly overcome the distrust, and credit be restored through the anxiety that capital should be employed. (T. T.)

CRIMES AND PUNISHMENTS. In the *Encyclopædia* a view has been given, from Blackstone's *Commentaries*, of the general nature and objects of crimes and punishments; and we shall now briefly notice the present state of this branch of science; reserving some farther observations on the whole subject, till we reach the article PUNISHMENT.

Experience abundantly and very lamentably proves, that a perfect code of laws, whether civil or criminal, is a matter of marvellously slow growth. Criminal law everywhere begins, where, amongst savages, it continues and ends, with the pursuit and gratification of the passion of revenge. Injuries, or presumed injuries, are punished according to the will and power of the injured. The first step in civilization is, the union of those who can avenge themselves for the protection of those who cannot. But, in some countries, ages elapse before, and in others it never happens, that any comprehensive view is ever attempted to be taken of the field of penal jurisprudence, an enumeration and classification of offences given, and the punishments deemed best adapted to prevent their recurrence annexed to them.

Progress of penal legislation on the Continent.

On the Continent, owing to a variety of causes, bolder efforts have been made in penal legislation than have ever been witnessed in England. The result has, undoubtedly, generally been far from successful; but this we may venture to say, that by such beginnings it is that the true course is pursued for the formation of a perfect penal code; and we can entertain no doubt that, rude as these efforts have been, the condition of the people, for whose use they were made, has been greatly benefited by them. Of all of them, it may be said, that they are

greatly deficient in respect of humanity, and the establishing a just proportion between crimes and punishments; and, moreover, lamentably erroneous in the including cases unfit for punishment, and the excluding others fit for punishment, still leaving a vast discretion to the judges; but they have, however, to the extent of the surface which they have covered, rendered a knowledge of the penal law practicable, and given great facility to its improvement by the recordation of its provisions.

In order that some notion may be formed of the progress of this science, we shall give, from one or two of the codes of criminal law now before us, a sample of their most prominent features.

The famous code collected under the auspices of Charles V., and known under the name of "*La Caroline*" (*Code Criminel de l'Empereur Charles V., Maestricht*, 1779), and which, we are told in the preface (p. viii.), "is properly the collection and confirmation of the laws which have been from time immemorial in use in the tribunals in Germany," is a very elaborate work on penal jurisprudence; and particularly, is extremely copious and minute on the subject of torture, which was, at that time, deemed a highly efficient and indispensable instrument of criminal procedure.

The code commences, very properly, in respect of arrangement, with the judicial establishment; but, after all, leaves it indeterminate with respect to the manner in which it is to be composed, and omits to give any exact and precise definition of the relative power of each of the several classes of individuals that enter into its formation. It appears clearly, that there were to be certain established judges, and that to them were to add themselves all the nobles, "*en qualité de juges et assesseurs;*" not precisely fixing in what quality they are to act, or whether the decision was ultimately to rest with the judges, under the advice, simply, or under the control of those other judges or assessors. Next follows, not, as might have been expected, an enumeration and definition of offences, and of the punishment annexed to them, but a minute account of cases, consisting of forty-one articles, in which torture may be employed to extract a confession of guilt; afterwards come several articles respecting proof by witnesses, and then the distribution of offences, not as such, but by the punishment annexed to them. An outline so entirely inconsistent with the true principles of criminal law, may be expected to be filled up with very little that is calculated to advance the ends of penal justice.

In this code the torture, as has been already observed, is most extensively employed. By article xli. p. 83, it is provided, that it shall be a sufficient ground for the applying torture, in order to produce confession, in the instance of a man accused of *incendiarism*, whenever, in other respects, his conduct shall be suspicious. It is upon similar slight grounds throughout the code, that this most dreadful instrument is brought into action. In other respects the code presents nothing remarkable; it is extremely defective in the arrangement of offences, but contains some observations with regard to the indications of guilt from accompanying circumstances, that might not be found altogether useless at the present day.

In the collection of edicts for the government of Corsica, * is the criminal code which, under the direction of Louis XV., was prepared for that country. After enumerating the most prominent species of offences, such as treason, murder, theft, and homicide, and giving a view, very far short of a complete one, of the field of criminal law, the framer of this code, in Title ix. (Vol. I. p. 24), has this article: "In respect of all other crimes and offences which are not mentioned above, we leave it to the prudence of the judges to condemn those who shall be guilty of them, to the punishment fitting for them, according to the exigence and circumstances of the case; not, however, allowing them the power of punishing with death, either natural or civil, except in the cases above enumerated;" leaving them, however, a considerable latitude of power in the cases so unprovided for, that is, in the cases in which they were thus invested with despotic authority, namely, that of punishing by hard labour in the gallies, either for a limited period or for life.

In the above two instances, we have specimens of two penal codes, formed at a comparatively early period. Next follow examples of others of a much more modern date. The first was drawn up by the direction and under the sanction of the King of Bavaria, by M. Bexon, and was published by him in a large folio volume at Paris, in 1807. It professes to contain a complete system of criminal jurisprudence, including punishments and police. Nothing, we think, can be more obvious, than the ingredients of which a code of criminal law ought to consist. The object is to prevent the doing certain acts. The means of preventing their being done is, by declaring that their being done shall be attended with certain painful consequences, to be attached under certain prescribed forms. However mankind may differ as to what acts are to be considered as offences, and what are the most effectual punishments to be adopted for the prevention of them, the general outline of the order we have just stated for providing against them, appears to be so simple and clear, that it is matter of no small surprise to observe that any other should be adopted. If a thing be meant to be prevented, it ought surely to be stated, and that in the most simple and intelligible terms, what it is that is so meant to be prevented, and, in like terms, the consequences that will ensue in case the inhibition be infringed.

M. Bexon has, however, thought it expedient to pursue a different course. He begins with a system of police, under the title of *Legislation de la Sureté;* and then proceeds to state the several purposes

* *Code Corse, ou Recueil des Edits, &c. publiés dans l'Isle de Corse depuis sa soumission à l'obeissance du Roi.* Paris, 1778.

to which this branch of administration is applicable. Now, the characteristic feature of a system of police is, that it is to serve for the prevention of offences; and thus we have, at the outset, the rules of a system of administration employed for the prevention of certain acts that yet remain to be stated. In the subdivisions of his work, an equal degree of confusion prevails. Take, for example, his principal heads, which are as follow:—" 1. Principes generaux. 2. Des auteurs, des complices et des fauteurs, des delits et des crimes. 3. Des peines en général, et du mode de leur execution. 4. De la recidive, de l'influence de l'age sur le caractère et la durée des peines. 6. De l'autorité paternelle et de famille. 7. Du devoir des juges, dans l'application et la graduation des peines, de circonstances excusantes, attenuantes, et aggravantes. 8. Des actions et de leur prescription. 9. Des absens ou contumace, et de la prescription des condemnations. 10. Des frais des procés criminels, et des dommages interêt. 11. De la grace. 12. De la diminution de la durée des peines, pendant leur cours, ou de la remission que le coupable peut obtenir par son travail et son repentir. 13. De la rehabilitation."—The disposition thus made of the matter of this part of the work in question is neither clear nor convenient. Crimes, punishments, tribunals, and procedure are mixed together, instead of being kept separate and distinct as they ought to be.

With regard to the penal code itself, he has adopted the old principle of division, and has classed offences under the several heads of, 1. Crimes against the public. 2 Crimes against persons. 3. Crimes against things. But what is new in his work, is the distribution of these several species of offences into three distinct classes, according to their supposed delinquency, and which he has denominated, 1. " Contraventions et fautes." 2. " Delits." 3. " Crimes." This is obviously an extremely unnatural and inapposite system of division, as it supposes that each class of offences is susceptible of only three stages of aggravation or extenuation; while, in fact, the same act is capable of varying, and continually does vary, and that by extremely minute steps, throughout all the gradations of guilt.

Penal Code of France.

M. Bexon's work was followed by the French penal code, which was decreed the 12th February 1810, and promulgated the 22d of the same month, and now forms the criminal code of France. The whole of the penal code itself, including punishments, is comprised in 114 moderately sized 8vo pages. It begins by declaring, that a violation of the law, cognizable by the police, is a *contravention;* that a violation of the law that is visited by a correctional punishment, is an *offence;* and that a violation of the law, that is visited by an afflictive and infamous punishment, is a *crime.* The several species of punishments employed are then enumerated, and are, 1. Death. 2. Hard labour for life. 3. Transportation. 4. Hard labour for limited periods. 5. Seclusion. 6. The Carcan (analogous to the pillory). 7. Banishment. 8. Civil degradation. 9. Imprisonment during a limited period in a house of correction. 10. Suspension, temporary, of certain civil rights. 11. Making satisfaction to the party injured. To these are added, in the cases specified,—the drawing a ball, to be attached to the feet; imprinting on the right shoulder, by means of a red-hot iron, certain letters; standing on the *carcan,* having above their heads affixed a writing in large and legible characters, mentioning the name of the patient, his profession, residence, punishment, and the occasion of it. Some of the punishments are also attended with certain civil disabilities, of which some are temporary, others perpetual. With regard to forfeiture, which figures to so great an extent in our own penal code, it is declared not to attach in any case as the necessary consequence of conviction, but to have place only when expressly pronounced to be a part of the punishment, and the instances in which it is used are comparatively few; and even when employed, the forfeited property remains liable to all just incumbrances, and to the obligation of furnishing to the children, or other descendants, a half of such part of their portion, as they could not have been deprived of by their father.

Offences are then divided into two classes. I. Offences affecting the public. II. Offences affecting individuals. Under the first class, the principal offences that are comprized are, Offences against the exterior and interior of the state, levying war, counterfeiting the coin, and malversation on the part of public functionaries, ecclesiastical and civil. Under the second head, Offences affecting particular assignable persons, such as murder and other personal injuries, perjury, and offences against property.

The manner in which the matter in this work is disposed, though not free from objection, indicates a vast progress in the science of penal legislation, both as it regards the humanity displayed in the catalogue of punishments, and the comparative lenity with which they are applied. There are some, however, in respect of which it would have been desirable to have found them less extensively employed; particularly the *carcan,* which is applied to a very wide class of offences; and as to which it is remarkable, that so nearly about the same period as that at which it figures so extensively in this penal code, the use of it should have altogether, with the exception of the case of perjury, been abolished in England.

In examining this code, it is impossible not to be struck with the undignified light in which the judges and officers of justice are placed; and the small value that is set on their integrity and honour, as qualities calculated to deter them from the violation of their duties. In the section relating to the administrative and judicial authority, it is declared that, whenever any judge shall, after it has been notified to him that a cause has been removed before a superior tribunal, proceed to pronounce judgment notwithstanding, he shall be punished by a fine of not less than 16 francs, nor greater than 150 francs; so again, wherever any judge shall enter the house of a citizen, in cases in which the law shall not have invested him with authority so to do, or in a manner not prescribed by the law, he shall be punished by a fine of not less than 16 francs, nor greater than 200 francs; and there are several other cases in

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which the misconduct of judges renders them subject to penalties similar in amount. To say the least of it, the policy of thus setting a price in money upon infractions of magisterial duty, is extremely questionable. In some cases it may exceed, but in most will probably fall short of the mischief; and it tends to produce a habit of laxity in the exercise of the judicial functions, and to diminish the confidence of the people in their due administration. For other cases of malversation on the part of a person exercising the judicial functions, the punishment is suspension, followed by such other penal visitation as the nature of the case may require.

Progress of Penal Legislation in England.

From the time of the Emperor Charles V. to the period of the promulgation of the French criminal code, a vast progress has undoubtedly been made on the Continent, on the subject of penal legislation; but notwithstanding the examples that have thus been set us abroad, the British legislature has shown no disposition to collect into one body of criminal jurisprudence the scattered fragments of law which now constitute the penal system of this country. It is reported, indeed, to have been said by Mr Wilberforce, in his place in the House of Commons, "That he well remembered that a great and lamented public character (Mr Pitt), at an early period of his life, had intended to have a digest made of the whole of our criminal code, with a view of lessening in a great degree the number of capital punishments which it contained, and the objections to which it was impossible to confute." * It is impossible sufficiently to lament that the intention thus said to have been formed was never carried into execution. Had the plan been attempted by Mr Pitt, little doubt can be entertained but that the objections which are now found to exist to the making even the most minute change in the criminal code, would have wholly vanished.

The greatest authorities, both dead and living, might be quoted in support of the necessity of a reformation in our system of criminal jurisprudence; but none appears entitled to more weight than that of Sir William Blackstone, who has expressed himself very decidedly in favour of a revision of our penal code. (*Commentaries*, B. IV. Ch. I.) That he did in fact entertain, or at least that he had very sufficient reason for entertaining this opinion, up to the time of his death, we had, till lately, no reason to doubt. The contrary, however, is now stated to be the case, and that on no less an authority than that of the present Lord Chancellor. In the debate that took place in the House of Lords, May 24, 1811, on the subject of Sir Samuel Romilly's bills for repealing the capital punishments annexed to the offences of stealing in dwelling-houses and shops;—stealing on navigable canals, and in bleaching-grounds, in Great Britain and Ireland—the Chancellor is represented to have spoken what follows:—"Considerable stress has, indeed, been laid on the authority of Judge Blackstone, as adverse to the present system. But I think his opinions on this subject, as contained in his *Commentaries*, are to be regarded as the offspring of an eager rather than a well-informed mind. It should be remembered, that the work was written at a period when experience and observation had not matured his judgment. I have, however, reason to believe, that after he had learned to listen to those great teachers in political science, his opinions underwent a considerable change; and that, in the latter part of his life, he saw the wisdom of the principles by which our criminal code is at present regulated." (Montague's *Collection of Opinions, &c.* Vol. III. p. 279.) Now, the sum of what is to be collected from Sir William Blackstone's *Commentaries* upon this subject is, that offences and punishment ought to be proportioned to each other by the legislature; and that capital punishments ought neither to be appointed for, nor inflicted in, the case of light offences. He says, (B. IV. Ch. 1.), "It is *a melancholy truth*, that among the variety of actions which men are daily liable to commit, no less than *one hundred and sixty* have been declared, by act of Parliament, to be felonies, without benefit of clergy; or, in other words, to be worthy of instant death. *So dreadful a list, instead of diminishing, increases the number of offenders.*" If, then, Sir William Blackstone really did, as is stated, change his opinion upon this subject, he must have come to the conclusion, that capital punishments, if provided for offences, whether inflicted or not, for such is represented as being the genius of the English criminal code, diminish rather than increase the number of offenders. But that the learned Judge ever did arrive at any such conclusion, notwithstanding what has been so confidently said, we have the strongest possible reason for doubting; we have, indeed, his own evidence that he did not; for we cannot bring ourselves to be guilty of so foul a reproach to the memory of this learned and eminent man, as, for a moment, to suppose, that on so important a point, involving the welfare of the whole community, he could have suffered his *Commentaries* to have been handed down, in their present state, to posterity, without taking pains to leave some indisputable record of the change that his opinions had undergone: he would not have left mankind in any such dilemma, as that of having to choose between his own solemnly recorded and deliberate judgment, and the insinuation of an alleged renunciation of that judgment.

But, however, with regard to this point, the fact may have been, we are much more inclined to adopt Judge Blackstone's opinion supported by reasons, than we are his opinion unsupported by any reasons; confirmed as his early notions have been, in our estimation, by the testimony of all subsequent experience.

One thing, at least, is quite clear, that whatever opinion may be entertained respecting the most effective system of penal law, the system ought to be rendered perfectly uniform, and that for offences equal in respect of enormity, punishments equal in

* *Opinions on the Punishment of Death*, selected by Basil Montague, Vol. II. p. 151.

respect of degree ought to be appointed. That in the penal code of this country, no such uniformity exists; but that, on the contrary, for offences essentially differing in degree, the same punishments are provided, the slightest investigation of our system of criminal judicature is sufficient to show. To steal a sheep,—to steal to the amount of five shillings privately in a shop,—or to commit the most atrocious murder, are all, at least in so far as the amount of the punishment is to be considered as a test (and for this purpose, there is no other criterion regarded by the English law), as offences equal in their degree of enormity.

It is impossible, then, that every one, independent of feelings of humanity, who has a due regard for his own personal security, and that of his reputation and property, must not desire to see a thorough reformation made in a branch of law thus imperfect and ill adapted to its professed ends. Let us see what are the materials of which we are in possession for this purpose.

With regard to the formation of a penal code, meaning the declaring what acts ought to be regarded as offences,—the reasons why they ought to be so regarded,—the giving a concise and intelligible description of them, and placing them in a clear and perspicuous order,—we have, in Mr Bentham's *Traités de Legislation Civile et Pénale*, not, indeed, a penal code completed and perfected in all its parts, but all the instructions that are requisite for the forming one, and which, to be adapted to use, will require merely the subordinate talent of filling up the outline that he has prepared. Previously to his time, Montesquieu, Filangieri, Beccaria, and others, but particularly Beccaria, had thrown most important lights upon this branch of science; but it is Mr Bentham alone who has travelled over the whole field of legislation,—who has shown the intimate connection that exists between all its several parts, and particularly the mutual dependence and relation of the civil and penal codes, and the impossibility of framing either of these portions of law without having previously taken a comprehensive survey of the whole. For the details, we must refer to the work itself. All that we can allow space for here is, merely to give an outline, and a short specimen of the principle of division pursued by the author.

Offences (*Traités de Legislation*, Tom. I. p. 172.) he divides into four classes:

1. Private offences. 2. Self-regarding offences. 3. Semi-public offences. 4. Public offences. Under these four general heads, and the combination of them, all offences may be classed and arranged.

Private offences. If an individual suffers from an offence, it must be either immediately in his person, or relatively, in respect to exterior objects. Exterior objects are either things or persons; things in which he has a property; persons, to whose services he has a right. The right to the services of certain persons constitutes the fictitious entity of condition in life. He has also an expectation of obtaining and preserving their good will, depending upon his honour or reputation. Reputation is therefore a species of valuable property, giving a title to gratuitous services. It is evident, then, that a man can suffer only in so far as he is affected in one or other of these points, which gives the division of private offences. 1. Offences against the person. 2. Against the property. 3. Against the reputation, and against the condition in life.

I. Offences against the person are comprised under the following heads: 1. Simple corporal injuries. 2. Irreparable corporal injuries. 3. Simple mental injuries. 4. Wrongful restraint. 5. Compulsion. 6. Banishment. 7. Confinement. 8. Imprisonment. 9. Homicide.

II. Offences against the honour or reputation. 1. Defamation. 2. Insulting language. 3. Usurpation of another's reputation. 4. Interception of another's reputation.

III. Offences against the person and honour. 1. Personal insults. 2. Threats. 3. Seduction. 4. Seduction by threats. 5. Rape.

IV. Offences against property. 1. Wrongful withholding of property. 2. Interception of property. 3. Divestment of property. 4. Usurpation of property. 5. Wrongful investment of property. 6. Non-reddition of services. 7. Waste of property. 8. Illegal detention of property. 9. Withholding the enjoyment of property. 10. Wrongful occupation of property. 11. Theft. 12. Fraudulent acquisition, namely, under false pretences. 13. Clandestine detention. 14. Extortion. 15. Insolvency.

For the manner in which these divisions are pursued, we must refer the inquisitive reader to this valuable work. This portion is followed by a view of the distribution of the parts of a penal code. Its titles are either general or particular. General titles are those under which are placed matters that belong in common to a great number of particular titles. The catalogue of general titles is as follows: 1. Persons under the authority of the law. 2. Means of justification. 3. Causes of aggravation. 4. Causes of extenuation. 5. Causes of exemption. 6. Compensation, or other satisfaction to be given to the party injured. 7. Punishments. 8. Of offences, principal and accessory. 9. Co-delinquents. 10. Violation of confidence. 11. Fraud. 12. Offences, positive and negative.

As to particular titles, they are all cast after the same mould. If the first is known, all the others are known. Here follows an example:—Title I. Simple corporal injury.—Section I. Text. Simple corporal injury is, where, without lawful cause, an individual occasions, or contributes to occasion to another, pain or uneasiness, without its being followed by any bodily injury.

To each of the clauses, requiring exposition on this definition of the offence, are appended notes, either referring to the general titles, or giving the requisite explanation, as the case may require.

By thus classifying offences in a clear and natural manner, and placing under each head of offence the punishment annexed to it, a correct and complete view may, with the utmost possible facility, be taken of the whole, and of every part of the body of penal law. Recollection of its provisions is thus aided, and the difficulties of promulgation reduced to their smallest possible amount.

Crimes and Punishments.

We are extremely glad to hear that these enlightened views, on the subject of criminal legislation, are in the way of receiving a practical application in Geneva. The citizens of that republic have appointed a commission, of which Mr Dumont, the editor of Mr Bentham's work, is a member, for drawing up a code of criminal law, which, when completed, will be laid before the legislature for its sanction. Considerable progress has, we understand, been made in this most important work; and if the labours of the commission should be approved of by the delegating bodies, we may expect to see a system of criminal jurisprudence, formed upon Mr Bentham's principles, in operation in the course of the ensuing year. We regret that the experiment should be destined to be tried upon so narrow a scale, and where many parts of a penal code, indispensable in a more extended community, will find no application; but we cannot sufficiently applaud the perseverance and admirable skill that must necessarily have been displayed by Mr Dumont, in expounding the advantages of Mr Bentham's system, in order to have introduced the consideration of so large a reform, as that of the adoption of an entirely new penal code.

Although no attempt has been made in this country to substitute to the existing criminal law an entirely new code, or rather, which is all that is required, with some considerable modifications, to collect the scattered fragments of our criminal law into one properly arranged body, and to apply to them the sanction of the legislature, yet the subject of penal jurisprudence has lately undergone considerable discussion in both Houses of Parliament. Very soon after he had obtained a seat in the legislature, Sir Samuel Romilly brought in a series of bills, the object of which was to mitigate, in certain specified cases, the severity of the penal law, by substituting for the punishment of death, transportation for life or for limited periods. The first bill which he brought in, and which afterwards passed into a law (48th Geo. III. c. 129.), was for repealing so much of the statute of the 8th of Elizabeth as takes away the benefit of clergy from persons stealing privily from the person. This was followed by bills to repeal acts having the effect of inflicting the punishment of death for stealing to the amount of 5s. privately in a shop, * for stealing to the value of 40s. in a dwelling-house, for stealing to the amount of 40s. on navigable rivers, and for stealing from bleaching-grounds both in England and Ireland. Of these bills the two last only have been adopted by the legislature; the rest, after passing the House of Commons, have been lost in the House of Lords. The principle upon which the above alterations were proposed, was in each instance the same, that of rendering punishments more certain, and thus offence less frequent, by removing the obstacle to the prosecution of criminals, which the severity of the penal laws occasioned. And the question throughout the discussions to which these bills gave occasion, was simply this, whether a severe punishment, never or scarcely ever inflicted, and which, in numerous instances, was indisputably proved to have had the effect of giving absolute impunity to delinquents, was, by the terror that it was alleged to excite, preferable to a less severe but uniformly inflicted punishment; and so obviously adapted, in respect of its amount, to the magnitude of the crime, that the most humane and conscientious would feel it a duty, instead of a reproach, to lend a zealous and active assistance to the giving effect to it. We forbear for the present entering into the arguments that were employed on this occasion, reserving what we have farther to say, to the article on PUNISHMENT, where we propose entering more fully into the whole subject. In the mean time, we cannot but entertain very confident expectations, that the reforms which Sir Samuel Romilly has projected will ultimately prevail. The apparent success that he has hitherto obtained has not indeed been greatly encouraging. But from all that we can learn, we are convinced that his high character, and the sound, discreet, practical, and intelligible views that he has connected with the subject, have obtained for it a much larger portion of the public attention than it has ever hitherto been its fate to experience. Almost down to the present period, mankind appear to have thought that penal law was a matter that concerned only lawyers and criminals; that lawyers alone could understand it, and that criminals are the only persons interested in the state of it. Different notions appear to be now, however, rapidly and extensively spreading, and principally, we believe, from the discussions to which Sir Samuel Romilly's bills have given rise. Every reflecting man is struck with the weakness of those reasonings, upon the faith of which it was that three of the above bills were rejected,—reasonings which involve the contradictory proposition, that the apprehension of the punishment of death operates as a preventative of certain crimes, though the returns show that it has never been inflicted on the crimes in question. (U. U.)

Crimes and Punishments || Cromarty.

Situation. CROMARTY, one of the northern counties of Scotland, comprehends what is called the Old Shire, situate between the Frith of Cromarty on the north, and the Moray Frith on the south, containing about eighteen square miles; and also a number of detached tracts scattered throughout the extensive county of Ross, annexed to Cromarty in 1685 and 1698, by which it has been enlarged to 344⅔ square miles, or 220,586 English acres: the largest of these lies on the western coast, at a distance of 50 miles from the Old Shire, and the whole belonged to George Viscount Tarbat, afterwards Earl of Cromarty, by whose influence the acts of annexation were procured. The valued rent is L. 12,897, 2s. 2d. Scots, and the real rent in 1811 was, for the lands, L. 10,860, 2s. 8d. and for the houses L. 480 Sterling; being, with the exception of Orkney and Shetland,

Extent.

Valued and Real Rent.

* 12. Anne, St. i. c. 7. For this offence, for the five years ending in 1811, there had been 598 commitments, of whom 120 were tried, 20 convicted, and not one executed.

Cromarty || Cryophorus.

the least productive of land revenue of any Scots county. The surface is much varied; the western parts are barren and mountainous, but on the sea coast, on the east, there are some very fertile spots which produce wheat, and all the other crops cultivated in Britain. About an eighth part of the whole is fit for tillage, and the best lands have a northern exposure. The climate is moist, particularly so in the western districts. During three-fourths of the year, the wind blows from between the south-west and north-west; the heaviest rains proceeding from the southward of west. The most severe snow storms are from the north-east. The average annual temperature is about 46° of Fahrenheit.

Surface.

Climate.

Town of Cromarty.

Cromarty, the chief town, has one of the most safe and capacious harbours in the kingdom, well adapted, from its situation, to become the depôt of trade in the northern part of Britain, and a place of resort for the royal navy when in the northern and eastern seas. A pier was lately built, to which Government contributed L. 7000. The principal manufacture is hempen bagging, valued at L. 25,000. There is also an establishment for some branches of the woollen manufacture, and an extensive brewery.

Antiquity.

The Old Shire, or Sheriffdom of Cromarty, insignificant as it was, both in extent and value, is of great antiquity. According to Dalrymple, the Urquharts were hereditary Sheriffs of Cromarty in the time of Edward I. The whole county, and the much more extensive county of Ross, through which it is interspersed, are now under the jurisdiction of one sheriff, who has two substitutes that hold their courts on the mainland, and a third in the Island of Lewis, politically attached to this district. The shires of Cromarty and Nairn elect a member of the House of Commons alternately. The town of Cromarty was a royal borough before the Union, but the magistrates being unable to pay their representative, petitioned to be relieved from sending one. The county also must have been distressed by the payment of what was then thought a heavy burden. To induce a gentleman to become its member on one occasion, it was necessary that the principal proprietor should become surety for his payment, and the engagement not having been fulfilled, a considerable estate was conveyed to him for his indemnification. The Gaelic language was introduced here only within these 40 years.

Representation.

The county of Cromarty is so much blended with that of Ross, and so similar to it in every respect, that it becomes necessary to refer for a more particular account of it to the article Ross-shire. The population will also be stated under that article, there being only one entire parish in this county, and eleven more shared between it and Ross-shire. (A.)

CRYOPHORUS, a name given by Dr Wollaston to an instrument of his invention, which serves to illustrate the theory of heat. It is described by him in the *Philosophical Transactions*, 1813, p. 71. The form of this instrument may be readily conceived without a figure. It is a glass tube, bent into the form of the Greek letter Π, with a ball of glass, D and E, at the end of each leg; the horizontal part of the tube is one or two feet long, the legs are two inches in length each; the diameter of each of the hollow glass balls is one inch. The ball D is half filled with water; if it contained more, the water in freezing would burst it. A vacuum is produced in the tube and ball E, by boiling the water in the ball D, whilst the capillary aperture in the ball E, through which the steam is issuing, is held in the flame of a lamp till the steam becomes weak enough to allow the melted glass to collapse and seal up the capillary aperture. When the apparatus is now allowed to cool, the ball D will be half full of water, and the ball E, and the rest of the cavity of the apparatus, will contain transparent watery vapour. In this state of things, if the ball E is placed in a freezing mixture of salt and snow, the water in the ball D will be speedily frozen, although distant from the freezing mixture all the length of the horizontal glass tube. The cold of the freezing mixture produces this effect by condensing the aqueous vapour in the ball E, and thereby producing a vacuum in the part not occupied by the water; thus taking off the pressure from the water in D, so as to allow another portion of that water to assume the state of vapour, a change of form attended with a reduction of heat to the latent state, or a production of cold. That sensible cold accompanies the passage of a liquid to the state of vapour, may be seen by swinging a thermometer at the end of a string, the bulb having been previously wetted with sulphuric ether; the rapid evaporation of the ether, accelerated by the renewal of air, causes the mercury in the thermometer to contract considerably, and to sink to the volume it has at the freezing of water, or lower.

Cryophorus || Cumberland.

The phenomenon exhibited by the cryophorus, is of the same nature as that produced by means of the air-pump in Professor Leslie's experiment, where concentrated sulphuric acid, dry basaltic porphyry in a state of powder, or some other body that has a similar faculty of absorbing vapour, is placed under the receiver of an air-pump. A saucer of water is placed under the same receiver; when water alone is relieved from the pressure of the atmosphere by pumping out the air from the receiver, a portion of the water becomes vapour, but this vapour presses on the water and prevents the disengagement of more vapour, so that, although cold is produced, it is not sufficient to freeze the water; but when water and an absorbent substance are placed in the receiver, the absorbent substance serves the purpose of taking up the vapour and removing the pressure from the water, so as to allow another portion of water to be changed into vapour, and consequently more cold to be produced; so that at last, after the pump has been wrought for some time, the water in the saucer freezes.

The same effect of freezing a small portion of water, would be produced if the water could be placed in a vacuum of a great extent, so that the vapour from the water, having room to expand, a sufficient quantity of water would be changed into vapour, and a sufficient quantity of heat thereby absorbed to change the water into ice. (Y.)

Situation.

CUMBERLAND, a county in England, at its north-west extremity, situate between 54° 6′ and 55° 7½′ north latitude, and 2° 13′ and 3° 30′ west lon-

Cumberland. gitude, is bounded on the north by Scotland and the Solway Frith; on the east, by Northumberland and Durham; on the south by Westmoreland and Lancashire; and on the west, for about 67 miles, by the Irish sea. It is, at a medium, about 50 miles long and 30 broad, within a bounding line of 224 miles, and contains 1516 square miles, or 970,240 acres, of which the mountainous district comprises more than a third, the old inclosures about a half, and the lakes and waters 8000 acres; the remainder being either commons capable of improvement, or lands recently inclosed. The principal divisions are called wards, a term synonymous with hundreds in other counties, of which there are five, namely, Cumberland, Eskdale, Leath, Allerdale above Derwent, and Allerdale below Derwent. The ward of Allerdale above Derwent is in the diocese of Chester, and all the others in that of Carlisle. The county contains one city, Carlisle, 17 market-towns, and 112 parishes. Carlisle and Cockermouth are its only boroughs.

Extent.

Divisions.

Surface. Cumberland presents every variety of surface. The south-west district is generally mountainous, rugged, and sterile, yet containing several rich though narrow vallies, with many fine lakes, islands, rivers, cascades, and woodlands, which, combined or contrasted in the view with the gigantic rocky masses around them, exhibit many remarkable scenes of grandeur, desolation, and beauty. Skiddaw, Saddleback, Helvellin, rising to the height of more than 3000 feet, belong to this quarter. The highest part of that immense ridge, termed the British Appenines, which, commencing in Derbyshire, extends in a continued chain into the Lothians, forms the eastern boundary; in which Crossfell, about 3400 feet high, surrounded with other lofty and barren eminences, retains the snow upon its summit nearly three-quarters of the year. The northern part of the county, what has been called the Vale of Carlisle, is in general flat, and a tract of low land, from two to four or five miles in breadth, winds along the western shore.

Climate. The climate necessarily corresponds with this variety of surface; in this, as in the other western counties, rains are frequent and copious, particularly in summer, and often also in autumn.

Soil. Black peat earth is the most prevalent soil in the mountainous districts, and is found, too, in the moors and commons of the low grounds. About half the cultivated land consists of dry loams, excellently adapted to the growth of turnips, herbage, and all sorts of grain. Fertile clays occupy but a small portion, but clay, wet and sterile, forms the subsoil in many parts.

Rivers. The principal rivers are the Eden, the Derwent, the Caldew, and the Esk. The Eden has its source in Westmoreland, near the borders of Yorkshire, and, pursuing a north-westerly course in its progress through Cumberland, passes Kirkoswald and Carlisle, and falls into the Solway Frith, near Rockcliffe Marsh, where it forms a fine estuary. The vale land on its banks is for the most part very narrow; in some places the high grounds approach to the water's edge. There are several salmon-fisheries on this river belonging to different proprietors. The Derwent rises among the frightful crags at the head of Borrowdale, in the south-west range of mountains, whence it is dashed from rock to rock, till it reaches Derwent lake, from which it flows onward through Bassenthwaite water, and, after being joined by the Cocker, near Cockermouth, falls into the sea, a little from Workington. The scenery along the whole of its course is singularly varied and interesting. The Caldew issues from the south-east side of Skiddaw, and joins the Eden near Carlisle, after a course of twenty-four miles, in which it gives motion to a number of cotton and corn-mills. The vale through which it flows is very beautiful, and its banks are well wooded. The Esk enters Cumberland from Scotland at a place called the *Moat*, and, flowing in a westerly direction by Longtown, falls into the Solway Frith; the Liddel, another Scotish river, which, in part of its course, separates Cumberland from Scotland, having joined the Esk after it has passed into England.

Estates. Landed property is much divided in this county, and the small estates are commonly occupied by their owners. Most of them are held under the lords of manors, by what is called *customary tenure*, which subjects them to the payment of fines and heriots on alienation, and on the death of the lord or tenant, besides certain annualrents, and the performance of a variety of degrading and vexatious services. According to the authors of the *Agricultural Survey*, printed in 1794, about two-thirds of the county were held by this tenure, in parcels worth from L.15 to L.30 of yearly rent. On large estates, also, the farms were in general rather small, few then reaching L.200 a-year, possessed on verbal contracts, or very short leases, and burdened, like the small estates, with payments or services, over and above a money rent; but leases for 14 or 21 years are now not uncommon.

Live Stock. The live stock consists of horses of rather a small size; cattle of the long-horned breed, with a few Galloways, to which, of late, the improved short horns have been added by a few great proprietors; and sheep chiefly of the black-faced heath variety. In a mountainous district, at the head of the Duddon and Esk rivers, there is a breed of sheep of a somewhat peculiar character, the ewes and wethers, and many of the rams being polled, their faces and legs speckled, and the wool finer than that of the heath breed. They belong to the proprietor of the lands, and have been farmed out with them from time immemorial, to *herds* at a yearly rent; and from this circumstance, it is said, have obtained the name of *Herdwicks*. There are a number of small dairies, at which butter and skim-milk cheese is made; the produce of each cow in butter is about two firkins of 56 lbs; and the quantity sent out of the county was computed, in 1794, to bring in upwards of L. 30,000.

Crops. All the common species of grain are cultivated, though in many instances with little attention to system, corn crops being often taken for several years in succession. Turnips and clovers do not yet enter into the rotation in many parts of the county. Potatoes are extensively cultivated. That excellent variety of oats, called the potatoe oat, is said to have been first discovered in Cumberland in 1788, from whence it has now spread over every part of the united kingdom. Among the farm implements, the single horse cart deserves to be noticed, as being almost exclusively em-

Cumberland.

ployed, and with great advantage; as it is not only by far the most convenient and economical carriage for the farmer, but is much less injurious to the public roads, than the waggons and heavily loaded carts in other counties. The agriculture of this county has been greatly indebted to Mr Curwen of Workington, both for the example he has given on his own farms, and for the spirit of inquiry and experiment which has been diffused by means of the Workington Society, of which he was the founder. His yearly meetings at Workington-hall are resorted to by agriculturists from most parts of the kingdom. The conduct of his large dairy near Workington, and the object of it, are alike deserving of commendation.

Manufactures.

The principal manufactures of Cumberland are calicoes, corduroys, and other cotton fabrics, established at Dalston, Carlisle, Warwick-bridge, and a few other places. Cotton printing is carried on to some extent in Carlisle; the manufacture of sail-cloth and cordage at Workington and Whitehaven; and checks and coarse linens in several of the market towns. In this, as in other thinly peopled and mountainous districts, domestic manufactures, such as woollen cloth, stockings, &c. supply a great part of the wants of the peasantry. The Seaton iron-works, on the banks of the Derwent, above Workington, a manufactory of coarse earthen-ware near Dearham, and paper mills in various parts of the county, with breweries, and a soap-work at Carlisle, comprise all the other manufacturing establishments of any note in this county.

Minerals and Fossils.

Cumberland abounds in minerals and fossils, from which a great part of its wealth is drawn. The most valuable are coal, black lead, lead, copper, iron, slate, and limestone.

Coal Mines.

Coal is found at different places in the eastern mountains, and also near Brampton in the northern part of the county, but in greatest abundance on the west side of the river Caldew, and thence to Maryport, Workington, and Whitehaven. A number of mines are constantly at work in this district, particularly near Whitehaven and Workington. The principal entrance to the coal-mines at Whitehaven, is by an opening at the bottom of a hill, through a long passage hewn in the rock, which, by a steep descent, leads down to the lowest vein of coal. The greater part of this descent is through spacious galleries, intersecting each other; all the coal being dug away, except large pillars, which, in deep parts of the mine, are three yards high, and twelve yards square at the base. The mines are sunk to the depth of 130 fathoms, one of them, the *King-pit*, 160 fathoms, and extended under the sea to places, where, above them, the water is of sufficient depth for ships of great burthen. Four engines, when all working together, discharge 1228 gallons of water every minute; another raises 9225 hogsheads every twenty-four hours. The seams all dip to the west about one yard in ten. Mr Spedding, the engineer of these works, observing that the fire-damp was not liable to be ignited by the sparks produced by the collision of flint and steel, many years ago invented a machine, in which, while a steel wheel was turned round with a very rapid motion, flints were applied to it, and, by the abundance of sparks emitted, the miners were enabled to carry on their work, where the flame of a lamp or candle would have occasioned explosions. But this contrivance was found not to be an effectual preservative; and this gentleman himself lost his life by one of those explosions which he had so sedulously attempted to prevent. The well known safety-lamps, now in general use, have been more successful. About 90,000 chaldrons are said to be raised annually. There are railways from the pits to the quay, over which large flues or *hurries* are placed, through which the contents of the waggons are speedily discharged into the holds of the ships. The coals are exported to Ireland, and the west of Scotland. The coal pits at Workington are from 40 to 90 fathoms deep. The uppermost seam is generally three feet thick, the second four feet, and the third or lowest that has been hitherto worked from ten to twelve feet.

Black Lead.

The famous black-lead mines are situated at the head of Borrowdale, in the south-west range of mountains. The mineral is found in irregular masses, generally imbedded in a blue rock, with a stratum of granite above it; and is only wrought occasionally as the demand for it may require. At other times, the mines are protected from pilferers by a temporary wall within, and the house of the steward built over the entrance.

Lead.

The principal lead-mines are in Aldstone Moor, on the south-east borders of the county. The ore is found in fissures nearly perpendicular, and not unfrequently contains a considerable proportion of silver.

Copper.

The most considerable copper-mines are near Caldbeck, at Hesket New Market in Borrowdale, and at Newlands in the vicinity of Keswick; but they are not now wrought to a great extent. The ore is commonly combined with sulphur, and usually contains both iron and arsenic.

Iron.

In the parish of Egremont, at a place called Crowgarth, is the most singular mine of iron-ore supposed to be in Britain. It lies at the depth of twelve fathoms, and the thickness of the band of ore is from twenty-four to twenty-five feet. In 1791 and 1792, the annual exportation from it to the Carron foundery in Scotland, and others, was upwards of 20,000 tons. Very good slate is found in the south-western mountains, and limestone in various parts of the county. Of this last, after being calcined, the exportation to the west of Scotland used to be very considerable. Among the other mineral or fossil productions may be mentioned *marble*, *spar* of various colours and forms, *gypsum*, *steatites*, and *porcelain clay* or *kaolin*.

Towns.

Cumberland contains a number of towns, few of them large or populous. Carlisle, Penrith, Wigton, Maryport, Cockermouth, Workington, Whitehaven, Egremont, and Keswick, are the most considerable.

Commerce.

The exports, chiefly from Whitehaven, Maryport, Workington, and Harrington, are coals, lime, butter, bacon, cured cod for the Liverpool market, and salmon and potted char for London. Since the East India trade was thrown open, Whitehaven has been among the first ports to embark in it; and it has long possessed a share of the trade with America.

Lakes.

The lakes and mountains of Cumberland have long attracted the admirers of the wild and beau-

Cumberland. tiful, in natural scenery. The lakes, including smaller pieces of water, called *tarns*, are fifteen in number; the finest are Ullswater, and Derwentwater or Keswick Lake. Ullswater is partly situate in Cumberland and partly in Westmoreland,—about nine miles in length, and from a quarter of a mile to one mile in breadth. Winding round the base of vast rocky mountains, it is seen only in successive portions; the scenery on its margin presenting new and striking objects at every stretch. The rocks in its vicinity are celebrated for reverberating sounds. The report of a cannon rebounds six or seven times, with pauses between, in which the sound of the distant water-fall is heard for a moment. This lake contains fish of various kinds, particularly trout, perch, and eels, and also char and gwinniard,—the last in considerable numbers. Derwentwater or Keswick Lake, is of an irregular figure, approaching to an oval,—about three miles in length, and one and a-half in breadth. It is seen at one view, expanding within an amphitheatre of mountains, rocky but not vast; broken into many fantastic shapes; opening, by narrow vallies, to the view of rocks that rise immediately beyond, and are again overlooked by others. Masses of wood frequently appear among the cliffs, feathering them to their summits; and a white cottage sometimes peeps from out their skirts, seated on the smooth knoll of a piece of pasture projecting to the lake. Its bosom is spotted by small islands, of which those called Lords' and St Herbert's, are well wooded. The celebrated fall of Lowdore, on the southern side of the lake, consists of a series of cascades, which rush over an enormous pile of protruding crags, from the height of nearly 200 feet.

Floating Island. What is called the *floating island* of Keswick, is said to appear occasionally on the side of the lake opposite to this fall, but only when the water in the lake is high, and then scarcely a foot above the surface. No satisfactory explanation has been given of this phenomenon; the size of the island seems to vary, according to different accounts; and its existence has not been unfrequently denied altogether. The waters of this lake are sometimes agitated in an extraordinary manner, without any apparent cause; and in a perfectly calm day, are seen to swell in high waves, which have a progressive motion, from west to east. This is ascribed to what is called *bottom wind*. The swell sometimes continues for an hour or two only, at others almost a whole day. Gilsland Spa, in the middle of a wild romantic valley, called the *Vale of Irthing*, about eight miles south-east of Bewcastle, has been long a place of considerable resort; and, independently of the medicinal qualities of its springs, presents attractions to visitors, particularly the painter and geologist, in the variety of its landscape and the disposition of the strata, exposed in the banks of the river in its vicinity.

Mountains. From the tops of the mountains in Cumberland, the views are alike extensive and varied. The summit of Skiddaw brings under the eye the Irish Sea and the German Ocean,—a chaos of dark mountains at a distance, with lakes seen dimly at the feet of the nearest, and a vast expanse of champaign country, bounded by the Irish Channel, and traversed by silvery thread-like streams in every direction. Upon the summits of the Cross-fell ridge, there frequently hangs a vast volume of clouds, reaching half-way down to the base of the fells. At some distance from this *helm*, as it is called, and opposite to it, another cloud called the *helm-bar*, is seen in continual agitation, while the helm itself remains motionless. When the *bar* is dispersed, the wind rushes from the helm, often with great fury, and sometimes on both sides of the mountains.

History. The early history of this county is involved in obscurity. In the tenth century it appears to have been in the possession of the Scots, but whether by a grant from the Crown of England, or by conquest, has been matter of dispute. It was long made the scene of plunder and bloodshed, by the savage incursions of both kingdoms alternately. At a conference held at York, Henry III., in full satisfaction of the claims of the Scots, agreed to assign lands to them of the yearly value of L. 200, within the counties of Northumberland and Cumberland, if lands of that value could be found therein, without the limits of the towns where castles were erected. But after this arrangement there still remained a tract between the two kingdoms, called the *debateable ground*, the resort of the worst characters of both, who continued to disturb the borders down to the Union of the two Crowns.

Antiquities. Of the Druidical antiquities of Cumberland the most remarkable is a circle of stones, about three miles from Kirkoswald, called *Long Meg* and *her Daughters*. The Roman wall may still be traced from the neighbourhood of Carlisle, both to the east and west, for some miles; where it enters Northumberland on the east, it is in some places five, and in others eight feet high. A great many coins, altars, and other vestiges of antiquity, have been discovered at the Roman stations on its line. In the mountainous parts, which have little intercourse with towns, the manners of the people are somewhat peculiar; and in the solitary dales, surrounded by the least accessible mountains, they have, perhaps, undergone little alteration for centuries.

Population. Cumberland sends six members to Parliament,—two for the county, two for Carlisle, and two for Cockermouth. The following abstract is taken from the census of 1811.—

Number of inhabited houses,	24,002
Houses building,	130
Uninhabited houses,	550
Families,	28,390
—— employed in agriculture,	10,868
—— in trade, manufactures, &c.	11,448
—— not included in these classes,	6,074
Males,	63,433
Females,	70,311
Total population,	133,744
Population in 1801,	117,064
Increase,	16,680

See Bailey and Culley's *General View of the Agriculture of Cumberland*. Hutchinson's *History of Cumberland*. Houseman's *Topographical Description of Cumberland*. Gilpin's *Observations on the Lakes*. (A.)

Currency ‖ Currie.

CURRENCY. We shall state and examine the various doctrines of political economy, connected with *metallic* and *paper* currency, under the article Money.

CURRIE, James, M. D. a physician who was an ornament to his profession, was born of a respectable family in the south of Scotland. His father was the minister of the parish of Kirkpatrick Fleming, near Moffat, in Dumfries-shire, and his mother, Jean Boyd, a woman of very superior understanding, was descended from the ancient family of Kilmarnock. They had six daughters, and an only son, the subject of the present article, who was born on the 31st of May 1756. Soon after this period, Mr Currie removed with his family to Middlebie, a parish to the living of which he had been preferred, and where he settled for the remainder of his life. He had here the misfortune to lose his wife, who died of a consumption, while her family were yet in early childhood; but the benevolent exertions of Miss Christian Duncan, a half sister of Mrs Currie, who undertook the management of their education, and the care of the household, and who performed towards them all the duties of a mother with exemplary fidelity, compensated for a loss, which, under other circumstances, would have been irreparable. Under the fostering care of this excellent person, young Currie was trained in the virtues and estimable qualities which have ever been the distinguishing features of his character.

He entered upon his grammatical education at the parochial school at Middlebie; and was afterwards sent, at the age of thirteen, to a seminary at Dumfries, then conducted by Dr Chapman, well known as the author of a work on education, and under whose superintendence the school had justly acquired a high reputation. He was fortunate in being admitted a boarder in the house of the doctor, and thus, in addition to the usual studies of the school, had the advantage of his personal instructions in mathematics and practical geometry.

The foundations of solid learning having thus been laid, young Currie was taken by his father on a visit to some friends in Glasgow, where the spectacle of the commercial activity, so strikingly displayed in that flourishing city, could hardly fail to inspire his sanguine mind with a similar spirit of adventure; and, relinquishing his original intention of qualifying himself for the medical profession, he was induced, with the concurrence of his father, to engage in the service of a company of merchants, who were going out on a speculation to Virginia. Nothing could turn out more unfortunately than this voyage, which happened to be undertaken at a time when those dissentions that eventually led to the separation of America from England were on the eve of breaking out, and where the trade between the two countries became in consequence totally interrupted. The treatment which Currie met with from the merchants with whom he was connected, and who probably were soured by disappointment, was harsh and ungenerous; and he had also to struggle with a long and dangerous illness that seized him soon after his arrival. To complete the series of his misfortunes, he also at this time lost his father, whose death at once bereft him of the only friend in whose counsels he could confide, under the complicated difficulties of his situation. But such is the spring inherent in the youthful mind, that the depressing influence of those misfortunes which happen at an early period of life is often merely temporary, and serve eventually to form a character of energy, which no other circumstances would have called forth. Having formed the determination of trusting solely to his own exertions for his subsistence, he generously divided among his sisters the scanty inheritance which had fallen to his share. Renouncing the pursuits of commerce, with which he had been completely sickened, he turned his attention to the political topics, which were then the universal subject of interest in America; and though convinced of the impolitic conduct of the English government towards that country, he was strenuous in maintaining the right it asserted of taxing the colonies. So warmly did he espouse its cause, that he published a series of letters in its defence, in an American newspaper, under the signature of " An Old Man." These juvenile essays, as far as he was known to be the author, procured him some reputation, but at the same time necessarily exposed him to the ill will of the adverse party; and he began seriously to think of embracing some profession which might raise him to that degree of independence to which he so honourably aspired. The example and advice of a near relation, Dr Currie of Richmond, with whom he went to reside, decided him in the choice of the profession of medicine, which, as we have already mentioned, had been his original destination. It was therefore settled, that he should go to Edinburgh, and after taking his degree at that University, that he should return to Virginia, with a view of practising at Richmond, for it was confidently believed that the war would not be of any long duration.

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In pursuance of this plan he quitted America, where he had spent very unprofitably five years of his life, and as the war had by this time precluded all direct communication with England, he proceeded thither by way of the West Indies, and after a voyage, in which he underwent many hardships, and was several times in imminent hazard of his life, arrived in London in 1776. From thence he repaired to Edinburgh, and immediately began his academic studies, which he prosecuted with unremitting assiduity and remarkable success, till the spring of 1780. He soon became conspicuous among the students by the extent of his acquirements, and the singular acuteness of his mind. He in particular distinguished himself as a Member of the *Medical Society*. The papers, which, according to custom, he contributed, bear the stamp of superior talents, and are curious as furnishing proofs that, even at this early period, his attention had been actively directed to subjects which he afterwards prosecuted with so much success, and illustrated by such important practical discoveries.

But whatever might be the satisfaction he derived from the high reputation he was acquiring at the university, the sense of his own dependence still weighed heavy upon his mind, and created an anxious wish to possess the means of supporting himself

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by some active professional employment, which might enable him to relieve his aunt and sisters from the charge of maintaining him while prosecuting his studies; a charge which, though it was afforded with the utmost cheerfulness, he was sensible must occasion a serious diminution of their comforts. Obstacles presented themselves in the way of every scheme that could be devised; but he was not to be deterred by difficulties from the pursuit of an object which he was eagerly bent upon obtaining; and the army affording the readiest field of immediate advancement, he procured an introduction to General Sir William Erskine, who gave him an ensigncy in his own regiment, with the office of surgeon's mate. He, himself, would have been contented with this humble station; but his friends encouraged him to aim at a rank more consonant with his abilities; and learning that a medical establishment was intended to be set on foot for the service of the British army in Jamaica, they advised him to apply for the appointment of physician, or assistant physician to the forces. One requisite, however, was indispensable before he could even appear as candidate for any office of that kind; namely, his having taken his degree. The rules of the university of Edinburgh precluded the possibility of his graduating before the ensuing June, although he had studied the full period necessary for that purpose. Fearful of missing the present opportunity of obtaining so desirable an appointment, and knowing that no time was to be lost in making application for it, he hastened to Glasgow, where he without difficulty procured a degree, after complying with the customary forms. He now immediately entered upon the arduous task of soliciting for the office which was the object of his ambition, and after furnishing himself with numerous letters of recommendation, and most ample and honourable testimonials from the professors of the university, and the many friends his merit had procured him among his fellow students, he proceeded to London. There he soon learned that the appointment, for which he had taken such pains to qualify himself, was already filled, having been given to a young Irish physician of considerable merit, through the interest of Mr Surgeon General Adair.

Though disappointed in his expectations of succeeding in the medical staff, he still resolved to pursue his fortune in the West Indies, and to endeavour to establish himself as physician in the island of Jamaica; a plan which, in case of his failure there, would still admit of his proceeding to Richmond, where he might ultimately settle, and have the advantage of being near his friend and kinsman, who had promised to give him every assistance in the commencement of his career. Dr Currie had already taken his passage on board a ship that was expected soon to sail in company with a numerous fleet. This fleet, however, happened to be detained for a considerable time, so that he passed the greater part of the summer in London, and had thus an opportunity of renewing his acquaintance with many of his collegiate companions, and of mixing with the society of the literary men in the metropolis, so well calculated to draw forth, and so capable of appreciating talent. The superior abilities which Dr Currie possessed were quickly discerned by those around him; and he was strongly urged to abandon his plan of voluntary exile, and to endeavour to form an establishment in some town in England, where his exertions might meet with an adequate reward. With the diffidence, which is usually attendant on real merit, he was disposed at first to regard the prospects thus held out to him as little likely to be ever realized: but the earnestness of his friends, and their confident representation of the probability of his succeeding, gradually inspired him with more sanguine views: and a severe illness which attacked him while he was yet deliberating on his future plans, concurred in determining him to relinquish his design of crossing the Atlantic. After a long and painful search for an eligible situation, during which he encountered many disappointments, he at length repaired to Liverpool in October 1780, having learned that a vacancy had occurred in the profession at that place, in consequence of the removal of Dr Dobson to Bath.

No choice could be more fortunate for Dr Currie than that of a town, which was so rapidly increasing in opulence as Liverpool, of which the leading inhabitants were distinguished for their enlarged and liberal views, and where the society afforded the most favourable field for the display of those excellent qualities, both of a moral and intellectual nature, which adorned his character. On his arrival he was unacquainted with a single individual, but by means of the introductions he brought with him, he soon became known to a great number of respectable families, and ever rose in their esteem and regard in proportion to the intimacy of their acquaintance with him. The suavity of his address, the elegance and variety of his conversation, the strength and maturity of his judgment, and the unaffected warmth of his benevolence, could not fail of producing the most favourable impression on all who met him in society, and of conciliating the attachment of those who enjoyed a more familiar intercourse. His company was soon courted by all who had any relish for the acquirements of literature, which in him derived a peculiar charm from the elegance of his taste. Another talent, the result of a happy union of great natural sagacity with quick feelings of sympathy, he possessed in a remarkable degree, that of inspiring the confidence, and securing the attachment of his patients. His success was now no longer doubtful. Gifted with the power of pleasing, and of commanding respect, his skill was exerted to the best advantage. He was elected one of the physicians to the infirmary, and soon rose to high eminence in his profession. His domestic happiness was in the meantime secured by his marriage, in 1783, with Miss Lucy Wallace, a lineal descendant of the Scottish patriot of that name, and daughter of a very respectable merchant in Liverpool.

Amidst the duties of an arduous profession, and the cares of a new establishment, he found leisure for the cultivation of literature and science, a field peculiarly suited to the exercise of his active and vigorous mind. Congeniality of tastes and dispositions soon led to an intimacy between him and Mr Roscoe, a name so well known in the republic of

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letters; and in conjunction with the late Mr William Rathbone, a gentleman distinguished by the excellence and high integrity of his character, they laid the foundations of a literary club, which deserves to be recorded as the first institution of the kind in Liverpool, and as being the germ of those splendid literary establishments, that have reflected so much lusture on a town, where the liberal and polite arts have flourished in alliance with the exertions of commerce.

But the progress of Dr Currie, though it had commenced so auspiciously, was unfortunately much retarded by ill health, which the fatiguing exertions he was occasionally required to undergo, tended considerably to aggravate. His assiduous and anxious attendance on Dr Bell, an intimate friend of his who had settled in Manchester, and who had been seized with a fatal disorder, together with the frequent journeys he was in consequence under the necessity of taking, in the midst of winter, generally at night, and in addition to his other professional labours, brought on a violent peripneumony, and placed his life for some time in imminent danger. This was followed by a train of pulmonary symptoms, which occurring in a frame already predisposed to consumption, a disease that had been very fatal in his family, were of a highly alarming nature. Experiencing, however, the good effects of carriage exercise, in mitigating, and even preventing the paroxysms of hectic fever, he determined upon undertaking a journey of some length; and the climate of Bristol being in repute for pulmonary complaints, he set out for that place in the middle of April, and, travelling by easy stages, arrived at the beginning of May. During the greater part of his journey his cough was severe, and he was obliged, in general, to lie at length in the diagonal of the coach. The returns of hectic were, however, rendered, by this mode of exercise, less regular and distinct than they had been. At Bristol he experienced the shock of witnessing the death of one of his sisters. She had been lingering under the same fatal disorder, which a year before had carried off another sister in her 17th year, and which had, by that time, attacked a third sister, whose life, as well as his own, there appeared little probability of preserving. Deriving no benefit from a residence of a month at Bristol, he resolved to try the drier air of an inland situation, and set out for Matlock, in Derbyshire. But here again his expectations of relief were disappointed, and it appeared on reflection, that continued exercise alone was capable of affording him any durable advantage. The hopes of bidding adieu to his yet surviving sister, who was hastening rapidly to the grave, conspired with this motive for travelling; and he again set out, directing his course towards Scotland. The salutary influence of motion became now more evident; and when he reached Dumfries-shire, his strength was so far recruited as to allow of his sitting on horseback for an hour together. But the hope which had prompted his revisiting his native land was cruelly disappointed; for, on the day on which he reached the end of his journey, the remains of his sister had been committed to the grave. His fortitude, however, did not forsake him; although so many victims to the disorder under which he laboured, impressed him strongly with the conviction that he himself was soon to experience a similar fate. He persevered in taking exercise on horseback, during a few weeks that he resided at Moffat; gradually increasing the length of his rides in proportion as his strength improved. As the progress of disease and debility seemed to be arrested, the hope and the love of life revived, and returning on horseback to Lancashire, by the lakes of Cumberland, he arrived at Liverpool on the 1st of September, having rode the last day of his journey forty miles. A very interesting narrative of his case, and the means he employed for his recovery, was drawn up by himself, and is given by Dr Darwin in the second volume of his *Zoonomia*, (p. 293.)

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The first occupation to which he applied himself during his convalescence, was prompted by a desire to do honour to the memory of his deceased friend Dr Bell. At the request of the members of the *Literary and Philosophical Society of Manchester*, he undertook a translation of the inaugural dissertation of Dr Bell, "*De Physiologia Plantarum*," which he accompanied with valuable notes, and to which he prefixed memoirs of the author's life. These were published by the society in the second volume of their Transactions. The biographical sketch he has there given, and which was the first acknowledged production of his pen, is drawn up in a style of peculiar neatness and elegance, and procured him considerable reputation as a writer. The delineation of the character of Dr Bell, in particular, which forms the concluding part of his memoir, is executed with a bold and masterly hand, and evinces a profound knowledge of the human heart. The failings as well as the merits of his friend are traced with a delicate yet faithful pencil, exhibiting a model of that manly candour, that seeks not to extenuate faults by disguising their extent, or concealing their pernicious tendency, but instructs us in the sources from which they spring, the good qualities to which they are allied, and the virtues with which they may be associated.

On being elected a member of the London Medical Society in 1790, he communicated to it an essay on "*Tetanus and Convulsive Disorders*," which was published in the third volume of its Transactions. In 1791, he presented to the Royal Society a paper containing "*An account of the remarkable effects of a shipwreck on the mariners, with experiments and observations on the influence of immersion in fresh and salt water, hot and cold, on the powers of the living body*," which appeared in the *Philosophical Transactions* of the same year: and soon after he was elected a fellow of the Royal Society. The inquiries which form the subject of this memoir, were but a part of a long series of investigations, in which he had been engaged for a considerable period and which had occupied him even when he was a student at the university. With a keenness of observation peculiar to himself, we find him intent in the collection of all the facts that bore upon the subject, and of which his sagacity made him readily perceive the application. Imbued with the genuine spirit of inductive philosophy, we find him proceeding with the caution

of a true disciple of Bacon, theorizing only when a sufficient foundation had been laid for general deductions by an accurate and extensive observation of facts. The more mature results of his experience and reflections were given to the world in 1797, under the title of "*Medical Reports on the effects of water, cold and warm, as a remedy in Fever and other Diseases, whether applied to the surface of the body or used internally;*" a work by which his reputation as a physician was widely extended, and which has effected a considerable revolution in the mode of treating the most frequent and fatal diseases. Few works, indeed, so strictly medical, have met with so great a number of readers out of the profession: in few do we find united, in such perfection, the graces of literature, with the severity of philosophical research. Dr Currie's talent is particularly conspicuous in his recital of the history of cases which fell under his observation. He places every circumstance deserving attention in so clear a light, and intersperses his own reflections with such judgment and effect, that we enter into all his reasonings without effort, and follow him through the minute details of symptoms and of medical practice, not merely without fatigue, but with a strong and increasing interest. The limits of the present article will not admit of our entering into any exposition of the contents of this valuable work, the fruit of so much experience and profound reflection; far less to trace the progress of his discoveries through all the generalizations which they received from his penetrating and comprehensive mind. It will be sufficient to observe, that it will ever be held a model of philosophical induction, in a science where the application of such a method is attended with peculiar difficulties; and that it has effected a very important improvement in the treatment of febrile disorders, which are among the most universally prevalent, and the most destructive to human life. The healing art is eminently indebted to Dr Currie, for establishing on solid grounds the salutary agency of cold applied to the surface of the body, under certain circumstances, and in certain modes, both in fevers and in many convulsive diseases. The practice of the cold affusion of water, or, in other cases, of cooling and moistening the skin by means of a wet sponge, has, indeed, been attended with extraordinary success; and although it had already been suggested, and even tried, by Dr Wright, it was reserved for Dr Currie to determine the circumstances which render its employment safe and salutary, and to point out the nature of its operation, on clear and rational principles.

We have already seen the interest he took in the party-discussions which agitated the public in America at the commencement of its alienation from England, and cannot, therefore, be surprised at the earnestness with which he viewed the political concerns of his own country at so eventful a period of its history. The first occasion on which he again obeyed the impulse of his feelings by the publication of his sentiments, was during his residence in London, on the occurrence of the disgraceful riots in St George's Fields, excited by religious fanaticism, and the cry of No Popery raised by Lord George Gordon. He wrote three letters on the subject in the Public Advertiser under the signature of Caius; they were afterwards republished in a collection of political tracts. These, as well as his writings in America, show that his earlier views of politics were conformable to the principles of the Tory party, in favour of which his education had given him an early bias. But in proportion as his experience of the world increased, and his judgment acquired strength and maturity, his solicitude for preserving the authority of those entrusted with power, which, in these seasons of turbulence, seemed to be chiefly threatened, gave place to a deeper feeling of anxiety for the interests of the community at large, on whom that power is exercised; and which, from the prejudices and passions inspired by the course of events, and the war of anger into which we had recently been plunged, appeared to him to be exposed to much greater danger. These sentiments were strongly expressed in his "*Letter, Commercial and Political, addressed to the Right Honourable William Pitt,*" which he published under the assumed name of *Jasper Wilson.* The mass of important information contained in this pamphlet,—the enlarged and profound views of political economy which it presented,—and the nervous and manly strain of eloquence in which they were enforced, attracted much attention; it was read with avidity, and quickly went through several editions. The name of its real author, although never publicly acknowledged by himself, could not long remain concealed; and the reputation which accrued to Dr Currie from this publication, in a limited circle of enlightened men, was gained at the expence of much odium, which it entailed upon him from the opposite, and, unhappily, more numerous party. A host of enemies, indeed, appeared in arms against him, and he was assailed in various quarters with the coarsest and most illiberal abuse. One writer among the number, apparently with the intention of doing him irreparable injury, took the unwarrantable licence of proclaiming him by name as the author, and used all his endeavours to provoke him to reply. But Dr Currie bore all the violence and malignity of these attacks with perfect evenness of temper, and abstained from gratifying his enemies, by engaging in a controversy, which he knew must be attended with certain detriment to his professional interests, while it could add but little to the force of what he had already published.

During an excursion which he made into Scotland in 1792, he had become personally acquainted with Robert Burns, whom it was impossible to know without being astonished at the glow of fancy, and fascinated by the social powers displayed by that brilliant and extraordinary genius. Dr Currie became an enthusiastic admirer of those productions of his rustic muse, which breathe the true spirit of poetry, and will immortalize the dialect in which they are conveyed. The family of this unfortunate man having been left nearly destitute at his death, a subscription was set on foot in Scotland for their relief, and a design was formed of publishing a complete edition of his works, for their exclusive benefit. Knowing the warm interest that Dr Currie had taken in his fate, he was strongly solicited by Mr Syme of

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Ryedale, an old and intimate friend of the Doctor's, to undertake the office of editor and biographer on this occasion, as being the person who was in every respect best qualified for such a task. The request was urged from so many quarters, that Dr Currie, however reluctant he felt to engage in a work, to the execution of which his multiplied avocations would prove a serious obstacle, at length yielded to the opinion of his friends, and to his own benevolent wishes in behalf of a distressed and deserving family. Accordingly, in 1800, appeared, in four volumes, 8vo, his edition of "*The Works of Robert Burns, with an Account of his Life, and Criticisms on his Writings; to which are prefixed, some Observations on the Character and Condition of the Scottish Peasantry.*" It is sufficient to say, that they fully equalled the high expectations that had been formed of them. The preliminary observations, from the pen of Dr Currie, are marked with his usual felicity of manner, and exhibit the same sagacity of remark, and liberality of sentiment, which pervade all his writings. Dr Currie had also the still higher satisfaction of succeeding in the object at which he had aimed,—that of securing, by his labours, a provision for the widow and children of the poet, to whose genius he was raising the monument it so well deserved.

His constitution had never completely recovered from the shock of the severe illness which he had suffered in 1784. He was seldom long free from threatenings of a return; but it was not till the year 1804 that his health began evidently to decline. Notwithstanding he sought relaxation by revisiting his native country, and enjoying the scenes where he had passed his early youth, the alarming symptoms reappeared on his return home, and he found it necessary, in the autumn, to retire from the fatigues of his profession, and quit the climate of Liverpool, where his loss, as may be well conceived, excited deep and universal regret. He spent the ensuing winter alternately at Clifton and Bath, and in March felt himself so much recovered, that he ventured to take a house in Bath, and recommence the labours of his profession. From the extent to which his practice very soon increased, there is no doubt that he would have been eminently successful, if his convalescence had been permanent. But all his complaints returning with new violence, he went, as a last resource, to Sidmouth, where, after much suffering, which he bore with manly fortitude and resignation, he expired on the 31st of August, in the 50th year of his age. His disease was ascertained to be an enlargement and flaccidity of the heart, accompanied with remarkable wasting of the left lung, without either tubercle or ulceration. Few men possessed a more amiable or estimable character, or a more enlarged and cultivated mind than Dr Currie. His kind and affectionate disposition was conspicuous in all the relations of social and domestic life, and endeared him to all around. As far as his influence extended, few men have exerted more active and judicious benevolence, or diffused more important benefits. Most of the public institutions, literary and benevolent, of which Liverpool can boast, were suggested, improved, or perfected by his advice and assistance. His political views were guided always by a pure, and latterly by an enlightened patriotism. His professional labours and discoveries are such as entitle him to an elevated rank among medical philosophers; while the important improvement that has resulted from them in the healing art, justify us in enrolling his name among the distinguished benefactors of mankind. (W.)

Currie || Cutlery.

CUTLERY, generally speaking, includes all cutting tools made of steel. Various countries and cities have, at different periods, been famous for excelling in the manufacture of some particular article, as Damascus for a beautiful sword-blade, which has hitherto baffled all attempts at imitation. If this blade is made (as is commonly supposed) by welding together extremely fine wires of iron and steel, laid alternately on each other, the dexterity required is such as must astonish the most active and experienced workmen of other countries. The peculiar wave, usually called the Water, so universally admired, is effected by the application of a weak acid to the polished surface of iron and steel; at Damascus sulphate of alumine is used, but any dilute acid seems to answer the purpose. The cutlery of England is deservedly held in high estimation in every part of the civilized world. The finer articles, as razors, penknives, scissors, and surgical instruments, are made of cast-steel, that is, steel purified and equalized by fusion. Dexterity and nice attention from the workman to a variety of circumstances, viz. the quality of the steel, nature of the fuel, accuracy in the processes of hardening and tempering, and many other minor considerations, are essential to the production of a good cutting instrument. Wootz, a steel from India, has lately been most successfully employed; and as public curiosity is highly excited on this subject, some account of it will be subjoined. For table-knives, and all cutlery of that description, sheer-steel is generally used; the tang and shoulder of the table-knife and fork are iron, united to the blade by welding.

The principal manufactories in England are at London and at Sheffield; the former are chiefly confined to articles of fine cutlery, as razors, penknives, &c. and the making of surgical instruments belongs almost exclusively to it. This most important branch of the trade is there carried to a very high state of perfection. Describing the process of making any one blade, a razor for instance, will suffice for most other articles of cutlery. The workman being furnished with a bar of cast-steel, forges his blade,—using a forge similar to that of a smith; the brow of his anvil and his hammer being convex, enable him to give to the blade a degree of concavity which greatly facilitates and accelerates the subsequent work of grinding. The blade is then fashioned more exactly with a file. It is again heated to a cherry-red colour, and instantly quenched in a cold fluid, commonly water. In this stage the blade is extremely hard, and requires to be tempered,—a process usually performed by brightening one side, then heating it over a fire free from flame and smoke, until the brightened surface assumes a straw colour. It is again quenched, and is then ready for grinding. As this method of tempering is liable to many objections, a tempering-bath, with thermometer, will be describ-

Cutlery.

ed, the superior advantages of which will appear too obvious for comment. But it now remains to grind and polish our blade; and this is so generally understood, as hardly to need explanation. The diameter of the stone is chosen according to the degree of concavity required; and, in polishing, care is necessary to avoid heating the blade by friction, which would render it useless. In London, the blade is generally the production of one workman, who is accountable for the whole manipulation, and who, if the work is faulty, can transfer no blame to another. At Sheffield, by division of labour, and the local advantages of coal and water to carry on extensive machinery, more dispatch is attained, and the manufacture afforded at a price considerably below that of London. Numerous attempts have been made to preserve from rust that beautiful polish given to the cutlery of England: the most effectual method is, to coat the surface with ethereal solution of gold, or what is still better, with muriate of platina. Mr Stodart has given his method of preparing and using these solutions, in the 11th volume of *Nicholson's Journal*. The process is interesting, independent of its utility, as a chemical experiment, proving the almost infinite divisibility of gold.

It is worth mentioning, that the iron procured from meteoric stones, is less susceptible of oxidation than any other. This is most probably owing to its being combined with nickel. Perhaps by artificially combining the two metals, we might obtain an alloy valuable for making instruments that, from necessity, are exposed to moisture. Having objected to the common method of hardening and tempering steel, on which process the excellence of the instrument so much depends, we proceed to state some improvements in that art. About twenty-seven years since, the late David Hartley, Esq. proposed the method of tempering with a thermometer to Mr Stodart, who still continues to practise it with perfect success. The following experiment is simple, and clearly exhibits and illustrates this manner of tempering: Let a plate of steel, finely polished, be so laid as to float on the surface of a bath of mercury, or of the fusible alloy of tin, lead, and bismuth; into the bath plunge the bulb of a thermometer, graduated up to 600 Fahrenheit,—a good Argand lamp will heat the bath. No change of colour will be visible on the steel, until the mercury has risen to 430, and it will then be so faint, as only to be perceptible by comparison with a plate that has not been heated. At 450 the colour will be a fine pale straw; this, as the heat increases, will become deeper, and successive changes will take place, till heated up to the boiling point of mercury.

The advantages of this mode of tempering will now appear obvious and conclusive; if, for example, a straw colour indicates the best temper for a penknife, the blade (or ten thousand blades) is suffered to remain in the bath until the thermometer rises to the number corresponding to that colour, when they are instantly removed from further increase of heat, and, consequently, are all of one temper. After the first experiment it is unnecessary for the bath to be metallic—oil will answer the purpose equally well.

Cutlery.

The late Mr Nicolson, who devoted much attention to the subject of steel, used in hardening delicate articles a bath of lead, and a metallic bath may, perhaps, frequently be advantageous in hardening as well as in tempering. A very ingenious method of hardening delicate steel-work was communicated to Mr Stodart by Dr Wollaston. The steel is enclosed in a tube, surrounded by the well known fusible alloy of eight parts lead, two tin, and five bismuth. The tube, with its contents, is heated in a furnace to redness, and then plunged into a cooling fluid. It is afterwards thrown into boiling water, by which the alloy is fused and the steel is left perfectly hardened, and unaltered by twisting, cracking, or in any way changing its shape. Several experiments have been made to ascertain the best cooling fluid, without any very satisfactory result. A large quantity of water cooled down to about 40 Fah. seems to answer as well as any thing hitherto tried. Mr Stodart quenched a scalpel in snow and muriat of lime, without perceiving any advantage from the extreme cold.

Having mentioned the wootz of India as highly valuable for fine articles of cutlery, we presume a brief account of it will be acceptable. For the introduction of wootz into this country, we are indebted to the Right Honourable Sir Joseph Banks, who submitted some of it to the experiments of intelligent workmen in the year 1795. It was soon found to contain valuable properties. From the cake (so the lump is called in the state in which it is imported) a small penknife was made. The forging was attended with considerable difficulty, partly owing to the unmanageable form of the cake, but more especially to the inequality of the mass; the steely principle being deficient in some parts, while others were quite overcharged with it. The penknife, however, proved excellent, and fully justified and encouraged further trials. The inequality in the mass was evidently owing to imperfect fusion, which defect will most likely remain until the Indian steel maker is acquainted with the formation and management of a proper furnace. If he was likewise instructed to pour the fluid metal into a mould, instead of allowing it to crystallize in the crucible, and afterwards to form it into bars with a tilt-hammer, it might be imported in the shape of English cast-steel, and probably at a price not greatly exceeding that article. This subject may, perhaps, be worthy the consideration of the Honourable Board of India Directors; in the meantime, those who wish to work in wootz, will find it advantageous to begin by a second and very perfect fusion, which, if done with discretion, will amply repay the expence and trouble. The workman will do well to attend personally to this second fusion. The Indian account of wootz-making is as follows: Pieces of forged iron are enclosed in a crucible and heated together in a furnace; the fire is urged by three or more bellows peculiar to the country; thus the wood is charred, the iron fused, and at the same time converted into steel. The metal is suffered to crystallize in the crucible, and in this state it is imported. This method of steel-making is neat and ingenious; its chief peculiarity consists in the wood not being previously charred; its appa-

rent defect in the fusion not being complete. When wootz is submitted to a second and very perfect fusion, it improves so much as scarcely to be recognised. This advantageous change is evidently owing to the whole mass being purified and equalized when in a state as thin as water. It is now fit for all purposes of fine cutlery, and is in fact infinitely superior to the best cast-steel of England. Is this owing to the using uncharred wood, or is it not rather, as suspected by Mr Stodart, owing to some particular property of the iron ore of India highly favourable to steel-making? The present state of chemical knowledge does not militate against the supposition, that this steel may be alloyed with one or more of the metals of the earth. We know that a very minute quantity of one metal is capable of producing extraordinary effects by combining with another. Sir Humphrey Davy's discovery is a fine example of this, viz. that mercury is rendered solid, and has its specific gravity diminished from 13 to 3 by combination with $\frac{1}{12000}$ of ammonium. Wootz requires from the workman every attention and care in forging. If overheated, it is useless. In hardening, it should be quenched at a cherry red colour; and, in tempering, be heated from thirty to forty degrees higher than our best cast-steel. Thus if a razor of cast-steel should be removed from the bath at 460, one of wootz may remain to 500, and even then it will be the hardest of the two. Notwithstanding its excellence, this steel has hitherto been little used by cutlers. Its Indian shape and want of homogeneity in the cake, required from the workman much patience and perseverance. The first experimentalists owe every acknowledgment to the President of the Royal Society, who furnished them not only with the metal, but also much valuable information respecting it. Their thanks are likewise due to Sir Thomas Frankland, Bart. who, by much patient investigation and labour, produced some excellent knives and other articles from this steel in its most refractory shape. Wootz is capable of being extended to all cutting-instruments. When increase of tenacity is desired, it may be alloyed with steel possessing that property in a high decree. This has already been done on a small scale, and the result justifies a repetition of the experiment. In a subsequent part of this work, it is probable we may be enabled to notice the further progress of wootz in this country.

We have already named a branch of cutlery, which, from its importance to the cause of humanity, claims some farther notice. Knives and other edge instruments for surgical operations, made and finished in the very best manner, are indeed invaluable. When fortunately the form and physical properties of the instrument are exactly to the wish of the operator, he is freed from many embarrassments inseparably connected with a bad or an indifferent instrument, consequently the sufferings of the patient are lessened both in intensity and duration. This truly desirable state of excellence is, confessedly, of difficult attainment. The choicest pieces of steel should be carefully selected (that from India merits a preference), and the skill and undivided attention of the best workman devoted to the whole manipulation of forging, hardening, tempering, grinding, and polishing. By want of ability or diligence during these various processes, the knife may be rendered totally unfit for the purposes for which it was intended. Finishing the edge, technically termed setting, is a work of much delicacy and skill. Very few acquire this art in the highest degree of perfection. The artist must be in a situation undisturbed by noise or conversation, and his attention exclusively devoted to the object on which he is engaged. This very nice and delicate process is performed on a hone, moistened with fine oil. The best are from Germany. They are imported in large quantities; not many, however, of superior quality, can be selected. The very finest of these are still inadequate to give the last finish to the edge. This is performed on a beautiful green stone, found in some parts of the old pavement of London; the only known material capable of giving perfect smoothness to the points of lancets, and other delicate instruments. These points, when made and finished in the very best manner, will perforate a thin piece of leather, by which they are usually proved, with such ease and facility, that no more resistance is sensibly felt, or noise made, than would be, if the point was dropped into a fluid, as water or oil. Nothing short of this proof of excellence is satisfactory; mediocrity cannot, at least ought not, to be admitted. These observations apply generally to every description of knife used in surgery; but the nature of each particular operation should be considered, in judging of the requisite degree of strength or delicacy of edge. Next in importance to the knives are the saws used in surgery. All of these must be of the best spring temper, which, for the cast-steel blade, is about 570 of Fahrenheit, and for one of Indian steel 600, or quite the boiling point of mercury. Of another class of instruments, viz. those denominated blunt, it will be sufficient to observe, that what is known by the name of sheer-steel is best adapted for the purpose. Case-hardened iron has been most improperly used; this hardening being very superficial. It is, in fact, converting the surface only into steel, by heating it to redness, in a close vessel, in contact with animal coal, such as charred bone, leather, or horn, and quenching it when red-hot in a cold fluid. Iron thus treated will take a beautiful polish; but, except for ornamental purposes, it ought never to be employed. Some instruments are necessarily made of gold or silver, as catheters, and other tubes and probes. When for these ductility is required, the metals should be unalloyed; the extra expence will be more than compensated, by the convenience of giving to the instruments, in all cases, the desired curve and form. The elastic catheter consists of a tube of wove silk, coated with a fine varnish, pretty generally supposed the caontghouc, or Indian rubber. This material, doubtless, forms a component in the varnish; alone, it will not answer, as, in using, it would soon be partially decomposed; when, however, digested with the letharge of lead and linseed oil, it forms a varnish of great beauty, elasticity, and durability, exactly adapted to make the fine surface of the elastic catheter. These valuable instruments were invented, and first made at Paris. They are now manufactured in

Cutlery || Cyanometer.

London, and finished in the most exquisite manner.

The handles of instruments, together with all ornamental parts, must, in a great measure, depend on the taste and choice of the purchaser. It would be well, however, to avoid such materials, as are known to produce chemical action, when in contact with polished steel. Ivory and mother-of-pearl are objectionable, as is ebony, although much used. The fine walnut-tree, such as the London gunmakers employ, is perhaps of all the woods the best for the purpose. Sandal-wood answers very well, although it by no means deserves all the credit given to it, as a preservative of steel from rust. The instrument-maker who wishes to excel, will do well to avail himself of every opportunity of witnessing the operative part of surgery; he can then judge how far the instrument is mechanically and physically adapted to its intention; and, if imperfect, is better able to make the requisite alteration. In London, every facility is most liberally afforded to encourage this attention. Some knowledge of anatomy and surgery would form a valuable part of the education of an instrument-maker.

British cutlery has deservedly obtained a high degree of reputation in almost every part of the civilized world; and it is of vast importance to the commercial interests of the country, that its character be preserved and rendered permanent. It must not, however, be concealed, that some danger does exist of this branch of our manufacture suffering from the use of very improper materials, from which considerable quantities are fabricated. Some years ago, a patent was obtained by a Sheffield manufacturer for a process of casting cutlery from a species of pig-iron. This iron is, from the superabundance of its carbon, highly susceptible of liquidity, and readily cast into the required form. In this state, the cast-iron cutlery is extremely hard, and as brittle as glass; it is reduced from this hardness by decomposition, being subjected to a strong and long continued fire in close vessels; and, in contact with iron ore, oxyde of iron, or any substance containing oxygen, with which the superabundant carbon combines, when kept at a high temperature, and flies off in the state of carbonic acid gas. In this way, table-knives, forks, razors, scissors, penknives, &c. are cast, saving all the labour of forging from the bar by the hammer.

This cast-iron cutlery is, when finished, not always, in appearance, distinguishable from that made at the forge; and, as it can be afforded at a much lower price, it ought, in common justice, to be specifically marked as *cast-iron*. The Sheffield manufacturers now see the absolute necessity of this, and either have, or are about to apply to Parliament for relief. This very fusible iron may be advantageously applied to many purposes. It is hardly necessary to add, that it is altogether unfit for any description of edge instrument.

The Editor is indebted for these valuable observations to Mr Stodart of London, whose eminence in the art of cutlery is well known to the public.

CYANOMETER, a word composed from the Greek, signifying a measure of the intensity of blue. On high mountains the sky appears of a deeper blue than on the plain, because the air contains a smaller proportion of opaque vapour. In order to have a comparable specimen of the shade of blue of the sky, at different times and in different places, Saussure contrived the cyanometer. It consists of pieces of paper, of three-quarters of an inch by one-half inch, each coloured with a different shade of Prussian blue. The piece number 1, is coloured of a very light shade, differing in so small a degree from white that it is not distinguishable from white at a distance, at which a black circular spot of one line and three quarters in diameter becomes invisible. The piece number 2, is of a shade of blue a little darker than number 1, so that it is not to be distinguished from number 1, when viewed from the distance before determined by the black spot. The other pieces are coloured with shades of blue successively darker, each being undistinguishable from that which precedes it, when at the distance ascertained by the black spot. The darkest piece differs little from black, and is not to be distinguished from black at the ascertained distance. The series begins with a white piece and ends with a black one: including these two the whole number of pieces is 51. These 51 pieces are pasted close to each other, and in succession from the lightest to the darkest, round the border of a circular piece of pasteboard.

Construction.

The colour of the sky is ascertained by holding up this pasteboard, and comparing it with the sky in an open place. If this comparison were made from a window the coloured pasteboard would not receive all the light from the sky, but would be illuminated in part by the light reflected from the building. The direct light of the sun should not fall on the cyanometer, as the instrument ought to be used in similar circumstances, and the direct light of the sun cannot always be had.

Mode of using it.

The colour of the sky depends on the quantity of opaque vapour in the air: the less vapour there is the darker is the colour of the sky. If the air were entirely free from opaque vapour, the sky would appear black. The particles of opaque vapour in the air reflect chiefly the blue rays, and thus give rise to the blue colour of the sky. The colour of the sky at the zenith is darker than at the horizon, because the quantity of vapour through which the eye looks at the horizon, is greater than at the zenith.

Results.

Saussure observed, that on the summit of the Col du Geant, from four in the morning to six, the colour of the sky at the zenith became darker by eleven shades. During the next four hours it became darker by four shades; at 10 it was at the darkest, and continued so till 11; from 11 to 6 it became lighter by 6 shades; and from 6 to 8 it became lighter by 12 shades; the colour of the sky during the night was light blue. A cyanometer was observed at the same time at Chamouni, and another at Geneva; the shades and the change of shades at the same hours were different in each, and different from those observed on the Col du Geant. At Geneva the colour of the sky was darkest from 10 to 12, as on the Col du Geant. In the morning the colour of the sky is not much deeper on the Col du Geant than on the plain at Geneva, which shows

that the air on the mountain is then as much loaded with opaque vapour as on the plain. In the evening the colour of the sky is lighter on the Col du Geant than at Geneva; the quantity of opaque vapour therefore is greater at that time of the day in the zenith of the Col du Geant, than in the zenith of the plain. In the middle of the day the colour of the sky is much darker on the Col du Geant than it is on the plain, which shows that the quantity of opaque vapour is at that hour less than in the plain. Hence it appears that the mid-day sun has a great effect in rarefying the opaque vapours on high mountains, and that it does not diminish in so great a degree, the quantity of opaque vapour on less elevated plains. Saussure, *Description du Cyanometre*, *Mém. de Turin*, 1788, 1789. *Journal de Phys.* 1791, Vol. I. and Saussure, *Voyage dans les Alpes*, § 2009. The cyanometer was employed by Humboldt in his travels in South America. (Y.)

Cyanometer || Dairy.

DAI

DAIRY or DAIRYING, that branch of husbandry of which the object is to convert the produce of the soil into milk, by means of the domesticated animals, and to prepare it for use in different forms; has been treated at some length in the articles Agriculture, Butter, Cheese, and Milk, in the body of the work, to which the reader is referred. All that is necessary here, therefore, is to present a condensed view of the subject, describing, under its leading divisions, the principal alterations or improvements that have been recently introduced into practice.

The only animal kept in considerable numbers for its milk, in this country, is the cow. Though it is still the practice in some parts of Britain to draw a quantity of milk from ewes, after their lambs are weaned, and a few goats and asses are kept chiefly for their milk, yet in the case of sheep, the milk is a very subordinate part of the produce, and the medicinal quality of the milk of the two latter species of animals, of which the number is quite inconsiderable, does not allow them to be considered as part of a dairy stock.

Milk is used either in the state in which it is drawn from the cow, or, after its component parts have been separated, in the shape of cream, or butter, or cheese, with butter milk, skim milk, or whey. Hence, to give a general view of this branch of husbandry, it is necessary to arrange dairies under three great divisions, according to the principal object of each, namely, *new milk*, *butter*, and *cheese* dairies. Nor is it any objection to this arrangement, that, at certain seasons of the year, or owing to temporary causes, it may be found necessary to unite the labours of all the three in any one of these divisions. It is enough that the chief purpose and general management be different, to entitle them to separate consideration, because these take their rise in the very different circumstances of each class, and give to it a determinate character. The treatment of the cows, and the value of their produce, are by no means the same in all the three, and the animals themselves would require to be selected with a view to the particular object of each; the cow that yields the greatest quantity of milk, and is on this account preferred for a new milk dairy, not being always the most profitable one in a cheese or butter dairy.

New Milk Dairies.

§ 1. *New Milk Dairies.*—It is only in or near large towns that dairies of this description can be established upon a scale of any extent, and there they are found in great variety. It will give a sufficient view of what may be considered the best systems of management, to mention the practice of the London and Edinburgh dairymen.

London.

Cows.

1. The cows kept for supplying the metropolis with milk are of a large size, with short horns, and known by the name of *Holderness cattle* (from a district of that name in Yorkshire), though they do not now all come from thence, but many of them from similar stock in that and the neighbouring counties. They are bought from the breeders when three or four years old, and in calf, and exposed by the dealers at the fairs and markets in Middlesex, particularly at Islington, where there is a fresh supply from the country every Thursday morning, by means of which the London cow-keepers are enabled to keep up their stocks. These cows are preferred on account of the quantity of their milk, without regard to its quality. A few of the cow-keepers have very large stocks, nearly a thousand being sometimes in the possession of one individual. The whole number required for the supply of London and its environs with milk is about 8500, the produce of which, a few years ago, was estimated at L. 38 a year each, or L. 323,000 in all, said to yield a profit of L. 6 *per* cow to their owners. But the sum actually paid for milk, including the profits of the retailer, is stated at L. 626,233 *per annum.*

The cow-keepers breed very few cattle, and those only from favourite cows, which become so merely from their giving much milk, and with very little attention to the choice of their bulls. Cows of this description are usually kept five or sometimes even seven years. When they are allowed to become dry, with a view to their being disposed of, they soon become fat on their former diet, and are then sold to the butchers.

Management.

During the night, the cows are confined in stalls. About three o'clock in the morning each has an half bushel basket of grains. From four o'clock to half past six, they are milked by the (retail) milk

Dairy. dealers, who contract with the cow-keepers for the milk of a certain number of cows, at so much for eight quarts. When the milking is finished, a bushel basket of turnips is given to each cow; and very soon afterwards they have an allotment, in the proportion of one truss to ten cows, of the most grassy and soft meadow hay, which had been the most early mown, and cured of the greenest colour. These several feedings are generally made before eight o'clock in the morning, at which time the cows are turned into the cow-yard. About twelve o'clock they are again confined to their stalls, and served with the same quantity of grains as they had in the morning. About half past one o'clock in the afternoon, the milking commences in the manner before described, and continues till near three, when the cows are again served with the same quantity of turnips, and, about an hour afterwards, with the same distribution of hay.

This mode of feeding generally continues during the turnip season, which is from the month of September to the month of May. During the other months of the year, they are fed with grains, cabbages, tares, and the foregoing proportion of rouen, or second cut meadow-hay, and are continued to be fed and milked with the same regularity as before described, until they are turned out to grass, when they continue in the field all night; and even during this last period they are frequently fed with grains, which are kept sweet and eatable for a considerable length of time, by being buried in pits made for that purpose. There are about ten bulls to a stock of three hundred cows. The calves are generally sent to Smithfield market at one, two, or three days old. The quantity of milk, given by each cow, on an average, is *nine quarts* a day, or 3285 quarts in the year. The weekly expence of food is estimated in the Middlesex Report at 10s. 3d., and the other charges about L. 5, 7s. *per annum.* In 1807, the retailer paid to the cow-keeper $2\frac{3}{4}$d., and sold it to the consumer at $4\frac{1}{2}$d. *per* quart, but it is alleged, that by taking off cream, difference of measure, and other means, the retailer obtains a profit of no less than 100 *per cent.*

Five or six men only are employed in attending near three hundred cows. As one woman cannot milk more than eight or nine cows twice a day, that part of the business would necessarily be attended with considerable expence to the cow-keeper, were it not that the retailer, as before observed, agrees for the produce of a certain number of cows, and takes the labour and expence of milking upon himself.

Every cow-house is provided with a milk room (where the milk is measured, and served out by the cow-keeper), and this room is commonly furnished with a pump, to which the retail dealers apply in rotation; not secretly but openly, before any person that may be standing by, from which they pump water into the milk vessels at their discretion. The pump is placed there expressly for that purpose, and it is seldom used for any other.

Edinburgh. 2. The greater part of the cows kept in Edinburgh are also of the short-horned breed, brought from the counties of Berwick Roxburgh, and Northumberland, and weigh, when fat, from 40 to 60 stones avoirdupois. They are purchased by dealers, who drive them to market when they are about to calve, or immediately after calving. Many of them are too old for being kept to advantage on the usual food allowed them in the country, or to be fattened on turnips; and part of them are purchased from hinds or married ploughmen, who have no means of fattening them. A cow which shows a great deal of milk, sells in Edinburgh nearly as high as a fat cow of the same weight. Dairy.

The cow-feeders of Edinburgh do not find it for their interest to keep their cows for more than one year, or even so long, if they can be fattened sooner. Their object is to have as great a quantity of milk as possible in the first instance; and when the cows fall off in milking, as they almost always do from between four and six months after calving, to prepare them speedily for the butcher. Most of the cows continue to give a good deal of milk while they are fattening, and even until they are sent to the shambles. It is expected they should sell to the butcher at the price paid by the cow-keeper.

Food. Their food in summer is brewers' and distillers' grains and dreg, wheat shellings or small bran, grass and straw; and in winter the same grains, dreg and bran, with turnips and potatoes, and hay instead of grass. When grains are scarce, cut or chopped hay is mixed with them. Some of them are sent to pasture in fields near the city, for about two months, during the best of the grass season; but even then a certain number must be kept in the house, for consuming the grains, which are purchased by contract for a whole year.

Management. With regard to management, the cow-keepers begin with grains, dreg, and bran, mixed together, at five o'clock in the morning; feed a second time at one o'clock afternoon; and a third from seven to eight in the evening. Grass in summer, and turnips or potatoes in winter, are given at both intervals. A small quantity of straw is laid below the grass, which absorbs its moisture, and is eaten after the grass; and, in winter, straw or hay is given after the turnips. Part of the turnips or potatoes are boiled, particularly when there is a scarcity of grains, and intermixed with them. The expence in summer is said to be 2s. $10\frac{1}{2}$d.; and in winter 3s. $7\frac{1}{2}$d. *per* day, for each cow. The cows are seldom milked more than twice a-day; for about a month after being bought, it is sometimes necessary to milk them three times. The common periods of milking, are six o'clock in the morning, from three to four in the afternoon, and, when milked a third time, nine in the evening.

Produce. Their produce in milk, when fed as already stated, may average about seven Scotch pints, or nearly twelve quarts and a half daily, *per* cow. When the cows are smaller, and not so well fed, five pints, or about nine quarts, is said to be the average. The price of milk in Edinburgh used to be 6d. *per* pint, but of late it has been sometimes lower in summer. This is said to be very little more than the price of the food. For interest of money, risk, expences of management, and profit, there is the dung, worth L. 3, 10s. for each cow; some savings on the cows while at grass, which costs only 1s. 8d. *per* day; and, probably a small advance of price may be common-

Dairy. ly got from the butcher, when the cows are skilfully selected and well managed.

There have been instances of cow-feeders contracting with others to retail their milk; but the practice is not common. The cow-keepers generally retail it themselves. In one instance, a guinea a-week for the milk of each cow was paid by retailers to a farmer in the vicinity of Edinburgh.

Comparing the London and Edinburgh dairies, there seems to be a difference in favour of the best of the latter, of no less than three quarts and a half *per* day. If this be the fact, perhaps it is owing to the whole of the Edinburgh cows being always in milk, none of them being kept for years, and bred from, as in the London dairies.

An extensive dairy has been established, within these few years, by Mr William Harley at Glasgow, which is conducted with an attention to the health and comfort of the animals, and the purity of the milk, that has, probably, no parallel in Britain. The cows are of the Ayrshire breed (see the Article AGRICULTURE in this *Supplement*), bought in generally either newly calved, or a few weeks before calving, and kept constantly in the house till they go to the butcher. Their food is much the same as in the Edinburgh dairies; but the turnips and potatoes, given in winter, are always prepared with steam. The average quantity of milk is eleven quarts daily from each cow. The cows are not farmed to milkmen as in London, but the milk is delivered to the consumer, from vessels so constructed and secured, as to prevent adulteration in its passage from the dairy.

Butter Dairies.

§ 2. *Butter Dairies.*—This class is not confined like the former to the immediate neighbourhood of towns, yet the principal ones are situate at such a moderate distance, as to allow of their produce being sent thither in a fresh state. Butter is made, indeed, in every part of the country, but it is, nevertheless, the chief object of a great number of dairies, which therefore form one leading division in this department of husbandry.

It does not appear that any particular breed of cows, as in milk dairies, is selected as most suitable for dairies of this description; nor that their food and general management differ materially from those of cows kept for other purposes. Even in dairies of this class, butter, though the chief object, is not one so exclusive as to prevent the cows from being employed as a breeding stock. With this last view, they are almost of every different variety, according as one or other breed is considered the most profitable, upon the whole, in different situations. They are commonly the breed of the district where the dairy is situate, and not, like the short horns kept in milk dairies, brought from other quarters, with a particular view to this description of produce. For an account of these breeds, see the Article AGRICULTURE in this *Supplement*.

Butter is made either from cream taken from the milk, or from the milk itself. Of the mode of preparing butter from cream, and also of the districts where this branch is extensively carried on, a full account has been given in the *Encyclopædia*. (See the Articles formerly referred to.) But the practice of churning the whole milk, which now prevails to some extent, particularly in the western counties of Scotland, remains to be described. Mr Marshall in his review of the Original Report of Cheshire, printed in 1794, mentions it in 1810, as a singular variety in the English butter dairy, that in Cheshire the milk and cream are churned together without any previous separation.

Butter made from Milk.

The practice of churning the whole milk has been thus described. The milk, when drawn from the cow, is placed in coolers about three inches deep, and stands from twelve to twenty-four hours; when the cream has risen to the surface, the coolers are emptied into a stand-vat, where the milk remains till churned. If another milking is ready to be placed in the stand-vat, before the former has begun to sour, the second also may be put into it; but if the first has soured, or is approaching to it, such admixture, it is said, would lead to fermentation and injure the milk. The utmost care is always taken not to allow the *coagulum* of the milk in the stand-vat to be broken, till it is about to be churned. If the house be of a proper temperature, the milk may stand from a day to a week without injury, till as much be collected as it may be convenient to churn at a time. No milk is ever churned till it has become acid and coagulated.

The operation is generally performed in plunge-churns of considerable size; some of them containing 120 Scotch pints, are worked by a single person; and when machinery is applied, 150 or 200 pints are churned at a time. In a few minutes after the operation begins, as much warm water is poured into the churn, as raises the temperature of the milk from 50 to 55 degrees of Fahrenheit (being that of the dairy house), to 70 or 75 degrees; the churning always going on while the water is slowly poured in. The milk will admit of a greater proportion of water in autumn when it is rich, than in spring when it contains more serum. Probably one pint of water may generally be added, one way or other, to every five or six pints of milk in the early part of summer, and one to four or five in winter. A certain proportion is considered indispensable, both for raising the cream and facilitating churning, but it is alleged that too much is often employed, for the purpose of adding to the quantity of the butter-milk. When milk is either overheated, or churned too hastily, the butter is always soft, and of a white colour. From two to three hours is a proper time for performing the operation of churning.

In Renfrewshire, where nearly all the milk is employed in the manufacture of butter and butter-milk, cows are sometimes hired by the year at L. 13 or L. 14.

Average produce in Butter.

The average produce *per* cow of the butter-dairies of England, according to Mr Marshall, is three firkins, of 56lbs. each, yearly. In Buckinghamshire, the rate is higher, a cow yielding 5lbs. *per* week, for 40 weeks, or more than $3\frac{1}{2}$ firkins. The annual consumption of London has been computed at 50,000 tons, or two millions of firkins, which, at the rate of three firkins *per* cow, is equal to the butter produce of 667,000 cows. This would be in the proportion of nearly a hundred weight to every individual in the

Dairy.

population, which is probably much above the truth, but the demands for the shipping and other purposes must be very considerable.

The packing, salting, and selling of butter are regulated by statutes, of which the most important is the 36th Geo. III. c. 86. By these it is enacted, that every vessel made for the packing of butter shall be marked with the maker's name and place of abode, and its own weight, and shall be of a size to contain 84lbs., called a tub, or a firkin to contain 56lbs., or a half firkin of 28lbs.; and severe penalties are imposed for the breach of these, and a variety of other regulations for the prevention of fraud.

The manufacture of butter leaves a large proportion of the milk, applicable to other purposes. When the whole milk is churned, the residuum is called butter-milk, which is sold in towns at a penny *per* Scots pint (more than two English quarts), and when delivered in a cleanly and pure state, it is esteemed a wholesome and nutritious article of food by the labouring classes. If the cream only is employed, there remains skim or sour milk, which in some places, as in Buckinghamshire, where it is reduced by repeated skimmings for cream, is given to hogs; but it is more commonly made into inferior cheese, yielding whey as the last product for the feeding of hogs.

Cheese Dairies.

§ 3. *Cheese Dairies.*—The practice of the principal cheese districts of England having been described in the *Encyclopædia* (see AGRICULTURE and CHEESE), we have little more to add under this head than a short notice of the cheese dairies of the west of Scotland, where the manufacture has been brought to much perfection, and is carried on to a great extent. The cheese of this district is known by the name of *Dunlop Cheese*, from a parish in Ayrshire of that name, where it is said to have been first made; but dairies of this description are now spread over all that and the adjoining counties; few of them are large, but the total number of cows is considerable. One individual had lately more than a hundred.

Dunlop Cheese.

When such a number of cows are kept as to yield milk sufficient for a cheese of tolerable size, at every milking, the milk is passed through a sieve (provincially termed a *milsey*), to remove impurities, into a boyne or vat, and formed into curd by a mixture of runnet. As milk requires to be coagulated as nearly as possible at its heat when drawn from the cow, and as it must cool somewhat in milking and passing through the sieve, it is necessary to pour a quantity of warm water into it in the curd-vat.

Where the cows on a farm are not so numerous as to give milk sufficient to make a cheese every time they are milked, the milk is stored about three or four inches deep in coolers, till as much is collected as will form one of a proper size. When the cheese is to be made, the cream is skimmed from the milk in the coolers, and, without being heated, is passed through a sieve or drainer, along with the milk which is drawn from the cows at the time, into the curd-vat; and the skimmed milk being heated, so as to raise the temperature of the whole mass to about the heat of new milk, and also passed through the drainer, the whole is coagulated by runnet, carefully mixed with the milk. The cream is put into the curd-vat cold, that its oily parts may not be melted.

The temperature at which the milk is kept, from the time it is drawn from the cows till it is formed into cheese, ought to be carefully attended to. To make it cool, and to facilitate the rising of the cream, a small quantity of cold water is generally poured into each cooler. If kept much warmer than 55 degrees of Fahrenheit, it will not properly cast up the cream, a thing necessary, even when the whole is to be formed into cheese, and it will very soon become sour. And, if it gets into a lower temperature, the milk never coagulates so well, the cheese made from it is soft and inadhesive, and the whey is separated with difficulty. It is not enough that the temperature be raised to the proper degree when coagulated; if it has, prior to that, become too cold, the heat at setting the curd will not do away the bad effects of the previous cold. It is said to be owing to the milk being allowed to cool too much before it is coagulated, that it becomes difficult to get it formed into cheese in winter, and that the cheese made at that season is so soft and tasteless.

Whenever the milk has coagulated, the whey is drawn off as fast as possible; and, to facilitate its separation, the curd is minutely broken, or cut with a knife. When the whey has been mostly extracted, the curd is put into a drainer, and again cut and pressed, to expel it more completely. It is next broken small, minutely mixed with salt, and put into the cheese-vat, with a piece of thin canvass round it; and pressure is applied till the whey is wholly extracted, and the cheese formed. It remains the first time about an hour, and afterwards three or four hours each time, in the press, getting a dry cloth, and its position being reversed every time it is replaced. Skewers are never put into the sides of the cheese to extract the whey, as is common in England.

Some have, of late, shortened the process of pressing, by placing the cheese, when it comes from the press for the first time, into water, heated to about 95 or 100 degrees, where it remains till the water falls to the heat of new milk. It is then dried well, and again placed under the press.

Salt is generally applied without measure or weight, but the proper rate is said to be half an ounce to every English pound of cheese, or 13 ounces to 24 lbs.

When the cheeses come from the press, they are exposed, for about a week, to a considerable degree of drought, and turned over twice every twenty-four hours, and afterwards laid on boards in a close cool room, and turned over twice a-week. The practice of sweating cheeses after they come from the press, and before they are laid up to dry, so common in England, is not approved of in Scotland, from an idea that it impoverishes the cheese, by melting part of its fat.

All the operations are carried on in Scotland by women. Men would think themselves degraded were they to assist in milking the cows, or making the cheese.

Besides one or two meal cheeses, in which the

Dairy. milk is fresh or sweet, a great deal of cheese is made from milk from which cream has been taken, and which has therefore been allowed to stand longer. This may be considered as a subordinate branch of the butter dairy, where butter is made from cream, as is still the most general practice; but the process does not require to be described, as it is not materially different from that which prevails in what may be more properly called a cheese dairy. Suffolk has been long noted for cheese of this description. Yet the celebrated Parmesan is said to be made of the same material; of this an account has been already given in the *Encyclopædia*.

Skimmed Milk Cheese.

Average Produce in Cheese.

The average yearly produce of cheese, from the milk of a cow, according to Marshall, is from 3 to 4 cwt. or more than double the weight of butter. If $4\frac{1}{2}$ quarts of milk commonly yield 1 lb. of cheese, a cow that gives 2000 quarts in a year should produce about 4 cwt. of cheese. It has been calculated that Cheshire alone makes no less than 11,500 tons in a year.

Whey Butter.

In many of the English cheese dairies, a quantity of inferior butter is obtained from the whey. In some parts of Gloucestershire, and in Cheshire, this produce is rated at half a pound *per* cow in the week, which sells at from a penny to twopence a pound less than milk butter. In some instances, what is called the "green whey," or that which is taken from the cheese-tub after the curd is formed, and the "white," or that which is expressed from the curd itself, are at first treated separately, the former being heated, as soon as it has parted with the curd, till it throws up a little white froth, and the latter set by till it is at least a day old. This last is then added to the furnace-pan that contains the green whey, from which mixture a substance is thrown up something in appearance between cream and curd, which is constantly skimmed off as long as it rises, and put into the cream mugs to be churned for butter. In the practice of other dairies, the white whey only seems to be used, and, after standing some time in these mugs, to acidulate for churning, the butter is obtained from it in the same way as from milk. The green and the white whey are, in other instances, both heated together, to which, if perfectly sweet, a little acid is sometimes added.

Flit-Milk.

Whey, whether butter be made from it or not, is sometimes subjected to further operations, to fit it for human food. *Fleetings* or *flit-milk*, made by pouring butter-milk upon whey, is a common beverage among the farm servants of Cheshire. But the purpose to which it is chiefly applied is the feeding of pigs, for which it is worth about a guinea for every cow. From the whey obtained from the milk of four cows, it has been calculated that a hog may, in one season, and with very little other food, be raised to the weight of 12 or 15 stone.

On the subject of cream, a product common to all the three classes of dairies, though of greatest value in the situation proper to new milk dairies, that is, in or near towns, it is only necessary to observe, that the sale of it affords a ready resource whenever all the milk cannot be disposed of in a fresh state, and also when, from the season of the year, or other circumstances, the manufacture of cheese must be discontinued. But there is yet another branch of dairying that deserves attention, namely, the fatting of calves, and this also may be, and usually is, carried on, at least occasionally, at dairies of every description. As milk is the chief, and in most cases their only food, its employment in this way may be considered as merely another mode of preparing it for the use of man. Dairy.

Veal.

Calves are either suckled or fed from the pail. In the county of Middlesex, where a great many are fatted by the first mode, the calves are kept in pens of seven or eight feet square. There are seldom more than four calves in one pen, which has only one door, and that is towards the cows. Particular care is taken to keep these places free from dirt of every kind, and well bedded with clean straw. On one side of every pen is placed a small trough, at such a height as to prevent its receiving any soil; this is always kept supplied with chalk, both in lumps and in powder, not with a view to render the veal white, as some persons erroneously suppose, but with the intention of preventing acidity in the stomach. Without this precaution, they would be liable to scour; which always prevents their thriving, and sometimes occasions the death of the animal. Some persons mix ground barley with the chalk, and others give them daily balls, made of linseed-jelly and barley-meal, to render them more fat, or fat in less time than could be done with milk alone. They are suckled at precisely the same time every twelve hours, generally at six o'clock. Any considerable deviation in time would occasion their being fretful, and that would impede their becoming fat. In about ten weeks they make the best veal; though they are frequently continued eleven or twelve weeks, with increase of weight; but, in that case, the joints of meat become large, and the grain of the veal coarse. The large calves also sell at a less price *per* stone, than such as are of a moderate size.

In the western counties of Scotland, where cheese dairies prevail, the calves are fed from the pail, suckling being considered injurious to the cows; and as the cows will not suckle any but their own calves, a calf would thus be confined to the milk of only one cow. It is the practice there to give to those that are to be reared, the first drawn milk, which is thin, and abounds with serum; and to such as are fatting, the last drawn milk of two or perhaps three cows. They have no other food; and bleeding is never used with a view to expedite their fattening, as in some dairies. A little bacon or mutton broth is administered, when a purgative is necessary; and runnet is used for an opposite purpose, if they begin to scour. But the ordinary management consists in merely supplying them with abundance of the richest milk, after the first two or three weeks, and keeping them dry, by means of plenty of litter, in a dark well-aired apartment, not exposed to the extremes of either heat or cold.

Dairy Management not uniform.

The operations of the dairy, in all its branches, are still conducted, perhaps more empirically than those of any other department of husbandry, though it would appear that science, chemistry in particular,

Dairy.

might be applied to discover the principles, and regulate the practice of the art, with facility and precision. We have heard it admitted, even by experienced dairymen, that the quality of their cheeses differs materially in the same season, and without being able to assign a reason. Every one knows how different the cheese of Gloucester is from that of Cheshire, though both are made from fresh milk, the produce of cows of the same breed, or rather, in both counties, of almost every breed, and fed on pastures that do not exhibit any remarkable difference in soil, climate, or herbage. Even in the same district, some of what must appear the most important points are far from being settled in practice. Mr Marshall, in his *Rural Economy of Gloucestershire*, has registered a number of observations on the heat of the dairy-room, and of the milk, when the runnet was applied in cheese making, on the time required for coagulation, and the heat of the whey after, which are curious, only because they prove that no uniform rule is observed in any of these particulars. The same discrepancy is observable in all the subsequent operations, till the cheese is removed from the press, and even afterwards in the drying-room. One would think the process of salting the cheeses the most simple of all; and yet it is sometimes, as in the west of Scotland. mixed with the curd; in other instances, poured into the milk, in a liquid state, before being coagulated; and still more commonly, never applied at all till the cheeses are formed in the press, and then only externally. Our limits do not permit us to describe this great diversity of practice, nor is it necessary, as it does not appear which method is entitled to a preference. A similar difference prevails in the number, description, and materials of the utensils employed, of which the most useful have been already noticed in the *Encyclopædia*. But it deserves to be mentioned, that, since the Articles formerly referred to were written, milk-coolers of iron, tinned within, have begun to come into use in Scotland, and are much approved of. The milk cools sooner in them than in wooden vessels; they are not liable, or only in a very small degree, to the same objections as leaden coolers, and they are easily kept clean. They were first made by Mr Baird of Shotts' Iron-works, in Lanarkshire.

[Ir]on Coolers.

As the first step towards scientific improvement in the practice of the dairy, it would be desirable to obtain a simple and accurate test of the quality of milk, or the proportion in which its three component parts, oleaginous, caseous, and serous, are combined in every instance. By means of this, it would not only be known beforehand, what the produce of milk, in each of these parts, ought to be under correct management, but also, by applying it to the milk of different breeds, and of the same breed kept on different kinds of food, the most profitable description of cows, and the most beneficial mode of feeding them, according to the purpose for which their milk was to be employed, would in time be determined. The changes which are understood to take place in milk during the gestation of the animal, and at certain intervals from the period of its parturition, and such also as depend upon its age, might perhaps be detected by the habitual employment of such an instrument.

[D]esiderata.

The importance of a test of this kind has not escaped the attention of ingenious men. Mr Dicas, a mathematical instrument maker in Liverpool, and well known by his invention for trying the strength of spirituous liquors and worts, many years ago constructed what has been called a lactometer, an instrument for ascertaining "the richness of milk from its specific gravity, compared with water, by its degree of warmth taken by a thermometer, on comparing its specific gravity with its warmth."—"If the principle be right" (says the author of the *Lancashire Report*), "by this may be discovered not only the qualities of the milk of different cows, pastures, foods, as turnips, potatoes, grains, &c. but also, probably, which may be the best milk, or best pastures for butter, and which for cheese." Another invention for the same purpose lately (June 1816) came under the notice of the Highland Society of Scotland, in a Report from a committee of their number, prepared by Dr Hope, Professor of Chemistry, in the University of Edinburgh. The subject of it is the patent aerometric beads, invented by Mrs Lovi of this city. The committee are of opinion, that these beads may be introduced into the dairy with a reasonable prospect of practical utility. The importance of such a test, as well as the difficulty of obtaining one that shall immediately indicate the quality of the milk, arising from the different specific gravities of its parts, and also the mode of using these beads, may be seen from the following observations of the committee:

Dicas's Lactometer.

Mrs Lovi's Beads.

"Were milk a liquor, the value of which, as of many other fluids, is indicated by its specific gravity, the application of the beads would be simple, and their testimony immediate. This, however, is not the case. Milk is a compound fluid, consisting in a great measure of water, and owing its valuable qualities principally to the curd and butter which it contains. The richest milk abounds in oil and curd, and the poorest in water. As the oil is lighter than water, and the curd heavier, the quantity of these ingredients is not indicated by the specific gravity; for were these substances in milk in certain proportions, they would not affect the specific gravity of the fluid, however large the quantity of them might be, the one counteracting the other.

"Milk possesses a specific gravity greater than that of water, which it derives in part from the saccharo-saline matters belonging to the whey, and in part from the curd; and it approaches more nearly the specific gravity of water, the greater quantity of water it has, or the greater the proportion of cream. Hence, a low specific gravity indicates either much richness or great poverty; and, consequently, the gravity of this fluid is not an immediate indication of its quality. The information given by the beads will, however, be valuable, if the specific gravity be examined after the cream is removed, as well as before.

"When milk is tried as soon as it cools, say to 60^0, and again, after it has been thoroughly skimmed, it will be found that the skimmed milk is of consider-

ably greater gravity; and as this increase depends upon the separation of the lighter cream, the amount of the increase, or the difference between the specific gravity of the fresh and skimmed milk, will bear proportion to, and may be employed as a measure of the relative quantities of the oily matter or butter contained in different milks. In this manner, therefore, by discovering by these beads the difference in the specific gravity of milk when new, and after being skimmed, the relative values of this liquor, for giving butter, may be certainly and easily determined.

"The Committee conceive, that it would be of much importance to ascertain, by carefully conducted experiments, the exact quantity of butter furnished by a given measure of milk of different degrees of richness, the specific gravities of which have been examined before and after the separation of the cream. By such experiments, the quantity of butter corresponding to each degree of change in the specific gravity may be determined; and then the aerometric beads will serve to indicate, not only the relative qualities of different milks, for the purpose of butter making, but also the actual quantity of butter that any given quantity of milk ought to afford.

"That such information may prove of consequence in regulating the business of the dairy, is too obvious to require illustration.

"The specific gravity of skimmed milk depends both on the quantity of the saccharo-saline matters, and of the curd. To estimate the relative quantities of curd, and by that determine the value of milk, for the purpose of yielding cheese, it is only required to curdle the skim milk, and ascertain the specific gravity of the whey. The whey will, of course, be found of lower specific gravity than the skimmed milk; and the number of degrees of difference affords a measure of the relative quantities of the curd.

"By a proper series of experiments, the quantity of cheese equivalent to each degree of the diminution of gravity in a given measure of this fluid, might be determined.

"Hence it appears to your Committee, that the aerometric beads may be employed to explore the quality of milk, in relation both to the manufacture of butter and cheese; and your Committee beg leave to direct the attention of the Society to this subject."

On the subject of new milk dairies, see Holt's *General View of the Agriculture of Lancashire*, 1795; Middleton's *Middlesex*, 1807; Sir John Sinclair's *Husbandry of Scotland*, and *the General Report of Scotland*, Vol. III. and *Appendix*, Vol. II. The best account of butter and cheese dairies is to be found in the writings of Mr Marshall, particularly in his *Rural Economy of Gloucestershire*. See also Wedge's and Holland's *Cheshire*; Smith's *Galloway*; Aiton's *Ayrshire*; and *Prize Essays and Transactions of the Highland Society of Scotland*, Vol. V. Part I. (A.)

DALGARNO (George), an almost forgotten but most meritorious and original writer, was born in Old Aberdeen, about the year 1626. He appears to have studied at Marischal College, New Aberdeen, but for what length of time, or with what objects, is wholly unknown. In 1657 he went to Oxford, where, according to Anthony Wood, "he taught a private grammar school with good success for about thirty years." (*Athen. Oxon.* Vol. II. p. 506-7.) He died of a fever on the 28th August 1687, and was buried, says the same author, "in the north body of the Church of St Mary Magdalen." Such is the scanty biography that has been preserved of a man who lived in friendship with the most eminent philosophers of his day, and who, besides other original speculations, had the singular merit of anticipating, more than a hundred and thirty years ago, some of the most profound conclusions of the present age respecting the education of the Deaf and Dumb. His work upon this subject is entitled *Didascalocophus, or the Deaf and Dumb Man's Tutor*, and was printed in a very small volume at Oxford, in 1680. He states the design of it to be, to bring the way of teaching a deaf man to read and write, as near as possible to that of teaching young ones to speak and understand their mother tongue. "In prosecution of this general idea," says an eminent philosopher of the present day, who has on more than one occasion done his endeavour to rescue the name of Dalgarno from oblivion, "he has treated in one short chapter, of *a Deaf Man's Dictionary*; and, in another, of a *Grammar for Deaf persons*; both of them containing a variety of precious hints, from which useful practical lights might be derived by all who have any concern in the tuition of children during the first stage of their education." (Mr Dugald Stewart's *Account of a Boy born Blind and Deaf. Transact. Royal Society Ed.* Vol. VII.) Twenty years before the publication of his *Didascalocophus*, Dalgarno had given to the world a very ingenious piece entitled *Ars Signorum*, from which, says Mr Stewart, it appears indisputably that he was the precursor of Bishop Wilkins in his speculations concerning "a real character, and a philosophical language." Anthony Wood tells us expressly, indeed, that Dalgarno communicated this piece to Wilkins before it was published, and that it was from it that the latter took the hint of his celebrated work. It is highly discreditable to Wilkins that he takes no notice whatever of the name of Dalgarno; and Dr Wallis must share the same censure. "That Dalgarno's suggestions, with respect to the education of the Dumb, were not altogether useless to Dr Wallis, will be readily admitted by those" says Mr Stewart "who take the trouble to compare his Letter to Mr Beverly published eighteen years *after* Dalgarno's treatise, with his *Tractatus de Loquela*, published in 1653. In this Letter some valuable remarks are to be found on the method of leading the dumb to the signification of words; and yet the name of Dalgarno is not once mentioned to his correspondent." That notice which the English Professors, who borrowed from them, ungenerously withheld from the writings of the Scottish Schoolmaster, was liberally bestowed upon them by a far greater man of another country, by Leibnitz, who has, on various occasions, alluded to the *Ars Signorum* in commendatory terms. The two works of Dalgarno above mentioned are exceedingly rare, and might probably be reprinted without any great risk of loss to the Publisher.

DEAF AND DUMB.

Deaf and Dumb.

The education of those unfortunate children, who, from birth or early infancy, have been destitute of the sense of hearing, and who are therefore precluded from receiving instruction in the ordinary way, must obviously be attended with peculiar difficulties. The senses being the only inlets to knowledge, and one of the most important of these inlets being closed, an extensive class of ideas, and of associations belonging to them, are totally excluded from their minds; and as the principal medium of mental intercourse does not exist, we are obliged to resort to new and less perfect channels of communication, and to employ peculiar methods and artifices in imparting knowledge. The invention and employment of means calculated to attain these purposes, constitutes a particular art, having for its object the instruction of the deaf and dumb; an art which, though it has not hitherto been dignified by any specific appellation, is so highly interesting in a moral, as well as philosophical point of view, that we conceive it incumbent upon us to present our readers with some account of the principles on which it is founded, and of the methods which experience has shown to be the most successful.

The proportion of children born deaf, and who must as a necessary consequence remain mute, was formerly supposed to be much smaller than it really is; as appears from the great number of cases which of late years have presented themselves to notice, since the formation of various establishments for the express purpose of their instruction. The celebrity which the Abbé de l'Epée acquired at Paris for his success in this art, drew forth into view a multitude of persons of this description who were never before suspected to exist. It was discovered that about two hundred deaf and dumb persons were living in Paris alone; a number which, calculating from the proportional population, would give above three thousand for the whole of France before the Revolution. The same apparent increase has been remarked in every town where similar institutions have been formed; from whence we may conclude that this congenital defect is by no means unfrequent.

Condition of the Deaf and Dumb.

It is scarcely necessary to observe, that the incapacity of speech in such persons as are designated by the term of *deaf and dumb*, results altogether from the want of the sense of hearing, and not from any physical imperfection in the organs of speech. Some fanciful writers, indeed, have ascribed it to an alleged sympathy between the organs of hearing and the organs of speech, by which the disease or defect of the former is communicated to the latter: but for this notion there does not appear to be the slightest foundation. All who are deaf from birth must necessarily be dumb; that is, they must be incapable of using language, of the sound of which they have never had the perception, and which they consequently could never attempt to imitate. From a strange inattention to this circumstance, it was usual, even with parents who noticed the slowness of their progress in comparison with other children, to ascribe it to a natural imbecility of intellect, which they took for granted was equally irremediable with the organic defect from which it originated, and effectually precluded all attempt at instruction, and all hope of rendering them useful members of society. Their minds were accordingly suffered to remain without culture; they were abandoned to themselves, degraded from the privileges of men, and exiled from the community of rational beings. To such a culpable extent was this prejudice carried, that it has been the practice, in some countries, to destroy as monsters all children who remained at three years old incapable of either hearing or speaking. In France the very birth of such children was accounted a sort of disgrace to the family from which they sprung: and the duties of humanity were deemed to extend no further in their behalf, than to the maintenance of their animal existence, while they were carefully secluded from the eyes of the world, either within the walls of a convent, or in some hidden asylum in the country. Abandoned thus early to their fate, and regarded as little better than ideots, it is not surprising that their future behaviour should have been such as might seem to justify the narrow views which prompted this ungenerous treatment. All motive to exertion being withheld, and all desire of improvement being repressed, the faculties soon languished and became paralysed for want of proper objects on which they could be exercised: and the man was sunk to the condition of the brute.

That the neglect and oblivion to which these wretched outcasts of humanity were consigned, were founded on very mistaken notions of their mental powers, has since been fully proved by a great number of instances in which the exertions of benevolent and persevering instructors to convey to them knowledge of various kinds, have been crowned with the most signal success. Yet the enterprise has still appeared one of the boldest and most arduous that could well be attempted, and every instance of success excited great astonishment even in persons of great knowledge and scientific attainments. So impressed was Dr Johnson, for example, with the notion of its extraordinary difficulty, that he represents the education of the deaf and dumb as "a philosophical curiosity." The study of the means by which these effects are produced must, therefore, be highly curious in itself, as throwing light on that science, which is interesting above all others, namely, the science of the human mind. But it has yet a still higher claim to our attention, as being directed to a purpose of great and immediate practical utility. What object can be more worthy of praise, or more congenial to a benevolent heart, than the redemption of a kindred spirit from the degraded and forlorn condition to which it appeared to have been

doomed? What occupation can be more delightful in itself than to awaken the dormant powers of the mind, to usher a new world to its acquaintance, to furnish it with the instruments and materials of thought, to open unbounded channels of intercourse with the living and the dead, to inspire the soul with fresh powers as well as motives to exertion, and, by supplying unlimited sources of intellectual and moral improvement, to place within its reach the purest and most elevated enjoyments of which our nature is susceptible?

Before entering into the detail of the particular methods adapted to convey instruction to the deaf and dumb, it will be necessary to inquire more precisely what is the general end we should propose to ourselves in their education, and what are the leading objects to which our endeavours ought, in conformity with this end, to be directed.

Objects in their Education.

It appears to us, that the great and fundamental object should be to qualify our pupils to hold ready communication with the rest of the world, that is, with persons who, having the faculties of hearing and speech, employ the current language of the country for purposes of mutual intercourse. They must, above all things, be taught the use of ordinary language, both as an instrument for expressing their own thoughts, and for understanding those of others. This qualification, it is evident, is absolutely essential to their becoming members of that community, from which, by nature, they would have been excluded, and to which it is our chief aim to restore them: it is essential to their deriving advantage from, or being of any utility to that community; a reciprocation of interests in which consists the true value and dignity of human nature. It is the only foundation on which they can hereafter build any solid acquirement. Once masters of language, they possess the key to all the sciences, and have access to every species of human knowledge; and their future progress will be proportional to their own diligence, and will be impeded by no obstacles but what their own exertions are competent to remove.

Language, or the ordinary medium of communication between men, is either spoken or written. To enable the deaf and dumb to speak, so as to be perfectly understood by others, and to enable themselves to understand readily what is said by persons speaking to them, is doubtless the ultimate stage of perfection in the art we are considering, and would, in fact, be nearly equivalent to a restoration of the privileges which nature had refused them. But whether we regard such perfection as attainable, and as worth the pains requisite for success, or whether we limit our views to more moderate qualifications, the knowledge of written language must still be an indispensable preliminary in every system of education. Let us first, therefore, direct our attention to the means of communicating to the deaf and dumb this fundamental acquisition. For this purpose, it will be necessary to have a clear view of the real nature of the class of ideas we are proposing to instil into the mind of our pupil, and of the real condition of that mind by which they are to be received.

Speech, being the expression of ideas by oral sound formed into words, is by far the most ready and universal mode of communication among mankind, and must therefore have long preceded the invention of written language, which has accordingly been formed upon the model of speech. Writing, instead of being the direct sign of ideas, as is the case with hieroglyphic characters, or more properly speaking, rude portraits of external objects, consists of symbols of the particular sounds composing oral language. Written words are, in fact, the signs of other signs: the one set of signs being addressed to the ear, and the other to the eye. The perceptions of hearing are intermediate links of association between the visible appearances of the written characters, and the ideas they are intended to convey to the mind. This circumstance is the source of the principal difficulties that stand in the way of all instruction to one who is deaf and dumb, in whom these intermediate perceptions can have no existence, and in whom a very different process must be employed for establishing in his mind a connection between ideas and certain signs; because, for want of this step in the process, he is incompetent to trace any regular correspondence or appropriate adaptation of these signs with the ideas they are designed to represent. To an ordinary child, whose ear is already familiar with the name of an object as spoken, and in whose mind the association of the sound with the corresponding idea is firmly established, the learning the use of the letters expressive of such sound is a comparatively easy step in his education. The infant lisping for the first time in broken and faultering accents the endearing name of its parent and its nurse, has in fact made a prodigious stride; he has entered already into human society, and has begun to participate in its blessings. His stock of words daily increases, he feels the value of his new acquisition; his ideas multiply, his powers are developed. Pleasure animates his efforts, and attends every stage of his progress: to learn his native tongue is a sport; to repeat what he has learned is ever a fresh source of delight. The mighty task is accomplished without any extraordinary interference on the part of the instructor, or laborious effort on that of the pupil. Who would dream of appointing a master to supersede nature in teaching the infant to speak? In this act, as in that of walking and running, the scholar of nature, where all around unconsciously aid her in the work, will be found the best proficient. Far different is the lot of that hapless and solitary being, who, born without the sense of hearing, is doomed to eternal silence, and is shut out from the inspiring influence of social intercourse. Debarred from the chief avenue to information at this early and critical period of his intellectual growth, the blandishments of his nurse, the prattle of his parents, the accents of praise or blame, the cry of pain or pleasure, in vain salute his ear. He is already but half a human being. Insulated from the main portion of the world, he must live chiefly within himself: his untutored mind must be left to its own slender resources in the acquisition of knowledge; and his progress must be therefore both slow and limited. He is an eagle, whose unfledged wings have been clipped, and who stalks on the ground, unconscious that his inheritance lies in another element.

Deaf and Dumb.

So deeply rooted do these associations become, which are thus established in our infancy, between ideas and sounds, that we cannot easily perceive how much we have owed to them, and how much of our subsequent acquisitions has been founded upon them; nor can we readily place ourselves in the situation of a child bereft of these advantages, so as to understand the nature and force of the difficulties with which he has to contend in every step of his progress. We might suppose, if we had not attended to these considerations, that the whole business of the tutor of the deaf and dumb, would be to point out the words to his pupil, while he, *by some other means*, communicated to him the ideas of which they are the representatives. It might be presumed that, by frequent repetition of the same process, the pupil could not fail to learn to connect the two together in his mind, and that he would have no occasion to trouble himself with whatever sounds the rest of the world might associate with these written characters; sounds, which, as to him they have no existence, so neither do they anywise concern him; and which may be regarded but as useless stepping-stones in forming a communication, which he is enabled to accomplish at a single stride.

Difficulties affecting him.

If such be the illusions into which a prejudice natural to every one tends to betray us, a little reflection on the laws by which associations between ideas are established in the mind, will be sufficient to dispel them. There is, manifestly, a great difference in the comparative facility with which ideas of different kinds become associated in the mind; and since memory consists in the strength and permanence of the associations, there is, consequently, a great difference in the facility with which different kinds of ideas become impressed and retained in the memory. Some ideas unite immediately, as by a natural affinity, and cannot afterwards be disjoined. In other cases, the connection is remote and difficult; and the ideas, like grains of sand, refuse to adhere together by themselves. Some intermedium must be found, which may cement and consolidate their union. Some analogy or relation must connect every new idea with some former idea already existing in the mind, before it can become the subject of recollection. The facility with which such connections can be formed, will depend much upon the number and variety of ideas already stored up, as well as upon the ease with which the successive transitions can be made from one to another. In casual and apparently arbitrary associations, there exist always a number of invisible links that compose the chain of connection; and the facility with which these links can be formed, determines the readiness of the association. We recollect a new name that we see written, from its resemblance to some other name previously known. But it is by means of the sound which it would have when pronounced, that this association is effected. That this is the case will soon become apparent, when we reflect on the difficulty experienced in retaining new and barbarous words, of which the pronunciation is difficult or grating to the ear. That we learn them by the ear more than by the eye, is also shown by the difficulty we should find in recollecting an arbitrary combination of the same number of consonants, which would, of course, not admit of being pronounced as a word. We should, in this case, be driven to the expedient of interposing vowels, in order, as it were, to give them breath, and transfer the task from the eye to the ear; although it is evident, that the addition of these vowels would increase the number of things to be remembered. All this will appear in a still stronger light, if we impose upon ourselves the task of learning by heart a set of characters, equally familiar to us with the letters of the alphabet, but which do not afford a similar resource, at least not in so direct a manner. Let us, for instance, open a book of logarithmic tables, and try to learn a page or two by heart, we shall soon be sufficiently convinced of the arduous nature of the undertaking. Just so it is with the deaf and dumb. The printed letters of a book are, to them, so many separate cyphers, distinguished, indeed, from each other by their form, but having no perceptible medium of association, and of which the apparently endless variety of combination, like those of the figures of logarithms, are sufficient to perplex the most sagacious observer, and baffle the most retentive memory. To them all distinctions into vowels and consonants, into long and short syllables; all the varieties of metre, and all the harmony of verse, have no existence; these belong to creatures of another world, from which they are doomed to an eternal exclusion. No wonder, therefore, that their own untutored efforts must be utterly inadequate to give them the remotest conception of the use of language; and that the records of history have never exhibited to us a single instance of a person deaf from birth, or even having lost the hearing at an early age, who has taught himself to read or write a single word.

But the deaf and dumb child lies under the farther disadvantage of possessing a smaller stock of ideas to set out with than other children. His faculties of observation have been less called into play, and the sphere of their operation has been more limited. The task of the instructor is, in this instance, analogous to that of the agriculturalist who redeems a savage land, which the plough has never loosened, and where the soil has not been fertilized by previous vegetation. He has to sow the first seed it has yet received, and must watch with anxious solicitude every stage of its growth and fructification. Deprived, at the outset, of the ordinary resources of communication, what means are we to employ in order to awaken the attention of our pupil; and how can we make him sensible of the object of our endeavours, and animate him to those exertions which are necessary to their success, and which habitual indolence have probably rendered difficult and irksome?

Exaggerated Statements of these difficulties.

But resources yet remain; and art has triumphed over all these obstacles, however numerous and formidable they appear. The deaf and dumb child has, in truth, still the means of acquiring a large stock of ideas of a certain class, and has a certain range of expedients by which he communicates with others. When we read the exaggerated statement which some authors have given of the deficiencies of such children, we can easily discern the influence of pre-

conceived theory in distorting obvious facts, and the false colouring which they have derived from a vivid imagination. "What," says Sicard, "is the condition of the deaf and dumb child considered in himself, and before any species of education has begun to establish connections between him and the rest of his species, or with that great family to which he appertains by his external form? He is a perfect nullity in that community; a living automaton; a statue, like the one imagined by Bonnet, and, after him, by Condillac; a statue, in which every sense in succession has yet to be unlocked, and directed to its proper objects, in order to supply the want of that one of which he is so unhappily deprived. His actions being limited to mere physical movements, prior to the removal of the envelope which cramped and confined his reason, he is not endued even with that instinct which is allotted to the brutes, and which is their only guide. He is, therefore, to be considered merely as a kind of walking machine, of which the organization, with regard to the effects that result from it, is inferior to that of animals. To denominate him a savage, is to assign him a higher rank than appertains to his miserable condition; for he is not even on a level with the savage, either in moral relations, which, to a certain extent, exist among all savages, or in means of intercourse with his fellow-creatures. With regard to the latter, indeed, he is much inferior to the savage, who can always communicate with others by language, however rude and inarticulate may be the sounds which compose it. These sounds are the means of fixing ideas in the mind, and afford the medium of comparison among those ideas, whence result combinations, judgments, and reasonings. Being destitute of these means of communication, and of these signs which fix and determine the power of recollection, all the impressions he receives are transitory, and the images fugitive; nothing remains in his mind, to which he can refer what is passing within him, and which can serve as a term of comparison. His ideas can only consist of what result from direct impressions; none can be derived from reflection. So that, being unable ever to combine two such ideas together, for want of the signs by which they could be laid hold of and retained, it is impossible for him to arrive at even the simplest process of reasoning." Condillac had already advanced the same doctrine, and has even gone the length of asserting, that the deaf and dumb, from birth, could have no power of memory, because they were deprived of those artificial signs, by which alone could the associations be fixed and rendered permanent. He compares their minds to those of brute animals, and even believes, that they are equally incapable of carrying on any train of reasoning.

But the results of observation are quite at variance with these conclusions derived from speculative reasoning. The real education of the deaf and dumb child, like that of him who is possessed of hearing, may be said to commence from the period of its birth. Dr Watson judiciously observes, that "persons born deaf are, in fact, neither depressed below, nor raised above the general scale of human nature, as regards their dispositions and powers, either of body or mind. They are human beings, individually differing from their kind only by an accidental defect. This defect is not such as to disturb the course of nature in the first stage of the growth of the mental faculties, though, while it operates as a bar to the acquisition of language, it retards, and almost precludes their expansion, after this stage." The whole of the visible and tangible worlds are still open to them; hearing at so early an age can give them comparatively but little assistance in acquiring the knowledge of external objects, and it is always some time before the discovery is made of their being insensible to sound. Still their sensibility expands, their affections are called into play, their passions are excited, nearly as in other children, though the means may be somewhat different. The visible marks of attention the child receives from those around, their caresses, their smiles and their frowns, all make their corresponding impressions on its tender mind: it lives in the looks of those on whom it is dependant. Its whole attention being turned to the study of these visible appearances, the only language which it has to learn, its proficiency in the interpretation of these appearances is comparatively greater. The gestures of its parent it acknowledges by responsive gesticulations, and expresses in this primitive language of nature all its feelings, conditions, and passions. Far from being the living automaton delineated in the closet, by theorising metaphysicians, it differs but little, in early infancy, from other children; and has even some advantages in the superior quickness of the eye, in the more expressive play of the features, and in the more ready apprehension of the slightest look or gesture it observes in others. It is remarkable, indeed, that the defect of hearing is generally not discovered till at an advanced period. Though the child remains mute, the real cause is not readily acknowledged: doubts and fears may, indeed, be entertained; but hope is kept alive by parental fondness, and inspires a thousand excuses. A year or two thus slips away, when it is gradually remarked that when a want is to be made known, or an approval or aversion expressed, it is done by a motion of the hand, head, or countenance; and in place of the loquacious and engaging prattle usual at his age, there is silence, or only inarticulate sounds. At times he is pensive and cheerless, no doubt feeling the disappointments necessarily resulting from incapacity to make himself fully understood by those about him, who, possessing a more perfect medium of mental intercourse, are too apt to be inattentive to the signs and gestures of the little mute. Yet his mind, instead of presenting a total blank, is, in fact, furnished with a multitude of ideas, arranged, indeed, after his own peculiar method, but still affording an extensive foundation for future attainments. Already has he established a species of intercourse with those around him, by the language of pantomime, derived from nature, and improved by his own ingenuity. Already does this simple language comprehend the use of nouns, pronouns, verbs, and above all interjections, though he is totally unconscious of the nature or existence of these grammatical distinctions; just as he has moved and

jumped, without being aware that he was effecting these actions by means of muscles and tendons, ligaments and bones.

It is therefore in the study of this species of pantomime, which is the native language of the deaf and dumb, that the first duty of the instructor consists. He must, in truth, begin by taking lessons from his pupil, and condescend to learn his language, in order to qualify himself for teaching him his own. He must study to familiarize himself with this language by frequent intercourse with his pupil, and engage his affections by repeated offices of kindness. No better preparation can be devised for the exercises which are to follow, than this intercourse of the heart, and interchange of confidence. Curiosity, a principle of action in which deaf and dumb children are generally by no means deficient, and which the judicious tutor will be careful to stimulate and sustain, will give him a strong hold in directing their exertions; on the other hand, they are very apt to be discouraged by the consciousness of their own inferiority, and are thrown into despondency at the idea of the immense interval which they feel must ever separate them from others. This feeling it is our duty to soften as much as possible, by removing the occasions which may give rise to it, and diverting the attention to more cheering views of their own powers, and to the prospect of their advancement. Perhaps it is even better, in many cases, that the truth should be in some degree disguised, and that they should be left, at least at first, in ignorance of the extent of the disadvantages they labour under. For this reason, we should not be disposed to adopt the plan practised by the Abbé de l'Epée, in order to explain to them the nature and uses of that sense, which they do not inherit. The following is the expedient which he hit upon for this purpose. Having collected his pupils round a large tub full of water, which was allowed to subside till perfectly at rest, he let fall into it perpendicularly an ivory ball, directing their attention to the undulations of the water, which struck against the sides of the vessel. He then moved a hand screen backwards and forwards rapidly in a room, so as to put in motion feathers, or other light bodies floating in the air at some distance; and explained to them that the room is as full of air as the tub was of water, and that the air set in motion strikes the sides of the room, as the waves did those of the tub. He next took up a repeating watch, and applying the fingers of his pupils to the hammer, made them feel the rapid succession of strokes which it produced. He now informed them that the ear of every person contains an apparatus of the same kind; and that the air, in its passage from the body, which has set it in motion, enters the ear and sets in motion the little hammer which is placed there. He gave his pupils to understand, that the reason why they do not hear, is because they have no such hammer in their ears, or because its motions are impeded, or the part on which it strikes is void of sensibility. "Whenever," says he, "I have given this explanation, I have observed it to make very different impressions on different individuals. Some expressed great delight at having acquired the knowledge of what hearing consisted in. Others became affected with profound melancholy, on learning that either they were destitute of so useful an instrument as this hammer, or that the one they had could not be used. The two first girls to whom this information had been imparted, could not conceal their ill humour, on finding that the house cat, and the canary bird, had each their little hammers in the ears, while they had none."

Teaching the use of Words.

The first and most important lesson to be taught to our pupil, is that written words have a meaning, and suggest to all persons of education the same definite idea. In teaching him the meaning of words, we should follow as much as possible the natural order in which they are generally acquired by those who have the sense of hearing. The first and simplest kind of knowledge is that which relates to the material world. We must commence, therefore, by instructing him in the names of external objects, beginning with those that are best known to him, and oftenest recur to his view. The name of an object of this kind, such as *hat*, may be written in large letters on a board; and the attention of the child being directed alternately to the name and to the object itself, which is to be presented to it at the same time, he will gradually be brought to understand that a certain relation exists between them, though what that relation is, we are not to expect that he will as yet be able to comprehend. The idea of this relation will become more distinct, when a similar process has been followed with regard to several other names. Occasionally we may find it difficult to convey by this means the least notion, that the one is the sign of the other: the child being unable to conceive how what appears to him to be an irregular collection of crooked lines, bearing no resemblance in form to the object pointed out in connection with them, can serve as its type. Experience, derived from the observations we may lead him to make, will, however, gradually teach him this lesson. Sufficient has been done to excite his attention; let us now, in his presence, call upon other children, more advanced in their education, to direct their eye upon these mysterious characters, of which the immediate consequence will be their pointing to the object. The effect produced by the word will be observed by the attentive pupil, and will make its due impression. Let three or four words be written at the same time on the board, and the corresponding objects placed on an adjoining table: on each of these words being pointed out to the advanced child, he will bring the proper article from the table. We shall now have an opportunity of ascertaining how far the proceeding has been understood by the younger pupil, by repeating the experiment on himself. If he lay hold of the proper object, it is clear that our meaning has been understood, and that the first step, the most difficult of all, has been accomplished.

Care must all this while be taken that our pupil impute not to any circumstance or quality in the words shown to him, different from that of their form, the significancy which he finds them to possess. We must show him, for instance, that their par-

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ticular situation on the board is not the circumstance from which it derives its meaning. This we can do by changing the order of the words, or by writing them on paper, and in different modes, preserving always the same precise form of the letters. It is evident that, in these preliminary exercises, we should give the preference to very short words, such as box, pen, shoe, cap, ring, &c. The association between the name and the object should be strengthened by frequent repetition; and also by occasionally varying the mode of impressing it. The process we have just described, for instance, should sometimes be reversed, the child being required to point out the name, when the object is shown to him. In fact, we should neglect no means of assuring ourselves that we are fully and perfectly understood, and that the associations we are labouring to establish are firmly rivetted in his mind.

We are, however, by no means to trust to a single associating principle in establishing these essential connections; we should multiply as much as possible the ligaments which compose the union. The child, while learning written words, should be made to copy them himself, so that, by dwelling upon their forms sufficiently, they may make an indelible impression on his mind. We should, from time to time, show him the objects, and require him to write their names himself. In these preliminary lessons, it is obvious that much assistance may occasionally be derived from drawings of the objects we may wish to point out, but which may not be immediately at hand. The Abbé Sicard has availed himself, with much ingenuity, of this mode of denoting objects as an introduction to the use of written words.

He begins, for instance, by tracing the outline of a familiar object, such as a key, on a black board, with a chalk pencil: and placing the object itself before the eye of his pupil, he will readily understand the resemblance of the design with what it is meant to represent. He does the same with other objects; and exercises his pupil in pointing out the objects denoted by each drawing, which of course is to him a mere amusement. He next writes the name of each object within the outline of the figure on the board; and after effacing the outlines, so that nothing but the words remain, signifies to the pupil that he is still to consider what he now sees as the representation of the drawing, that is, of the object denoted by the drawing. These methods, which are susceptible of variation according to circumstances, and the ingenuity of the instructor, are to be understood as applicable only to the early lessons; for, after the pupil has once thoroughly derstood the value and use of words, all the drawings on the slate should be laid aside, and the more useful medium of written language should be exclusively resorted to.

With regard to the choice of objects, of which the names may compose the first lessons, we should select those to begin with which are of immediate interest and utility, such as the different parts of the body, articles of dress and of furniture, and common instruments in most frequent use. We should see that every thing that is learned is learned perfectly, by frequently going over the same lesson, so that they may all be deeply engraven on the memory. We must recollect that repetition is the principal means of impressing the memory; and this is the more necessary in the case of the deaf and dumb, as a principal barrier to their acquisition of language consists in their having few means of reviewing words and phrases but by direct instruction, or prescribed study.

Employment of Engravings.

But our pupil is not always confined to his apartment, and he can hardly take a step beyond its threshold without meeting with something that he knows very well by sight, and of which it will be useful to him to know the name. We cannot remove it into our school room, to teach him its name there: nor can we very conveniently carry our writing tablets with us on all occasions. Engravings of such objects will, however, readily supply us with the means of extending our instructions to them also; and, by furnishing us, in small compass, with the lines that bound their visible appearances in perspective order, will enable us to preserve the remembrance of them, and to keep them in readiness for every purpose. Association will at once recall to our minds the properties that manifest themselves to our other senses, and enable us to read and interpret this picture-language as we would any other collection of artificial signs. A vocabulary, on the plan originally recommended by Locke, consisting of "those words standing for things which are known and distinguished by their outward shapes, accompanied by draughts and prints," will therefore be of great utility, and shorten the labour both of the teacher and learner. For this express purpose, Dr Watson has had a set of plates engraved, containing delineations of objects most generally met with, and commonly known. These engravings are annexed to his book of *Instruction of the Deaf and Dumb*, and represent above 600 different objects, being comprised in 80 octavo pages. They are accompanied by a printed vocabulary, consisting of the names of all the objects thus represented, as also of most of the words explained in the earlier lessons, before the engravings are had recourse to. The first time of going through this vocabulary, the heads or generic names under which the objects are classed are not regarded. But, in a subsequent revision, these are particularly attended to, and their relations to the subordinate specific names are fully explained.

Analysis of Words into Letters.

The analysis of words into letters is the next step of importance in the early education of the deaf and dumb. It should follow almost immediately upon their complete comprehension of the use of words. They should be shown, as soon as they have learned a small stock of words, that these words are formed from a certain limited number of characters, or letters of the alphabet. Various modes of familiarizing them with this knowledge may be adopted. One of the most simple is, to have each letter written on a small piece of card, of which a number, disposed in parcels, and arranged in proper order, may be contained in a box. After making the child observe a written word that he already knows, we should point out to him the first letter, and take out the same letter from the box; then, indicating to him the next, we

may conduct his hand to the proper letter in the box, and continue this operation till the word is completed. He will soon reject our assistance, and seek the letters for himself. By practising a little in this way, he will very soon have learnt the alphabet, and will understand its use; and will be able, of his own accord, to compose known words with the letters thus furnished him. He must all this time be diligently exercised in writing, so as to acquire facility in forming and joining letters in a running hand. He must be taught the various forms of letters, according to the different ways in which they are used, and the purposes to which they are applied. The capital, small, and double letters, both in the roman and italic types, must be perfectly learnt, by frequent and daily practice. Writing being an operation to which deafness offers no impediment, nothing particular need be said respecting the method of teaching it. It is proper, however, to remark, that it cannot be taught too early, as, agreeably to the observations formerly made, every variation in the mode of exercising the attention to any set of objects is of material assistance to the memory of those objects.

Manual Alphabet, or

It will also be advantageous to instruct our pupil, as soon as he is familiar with the use of letters, in another mode of visible communication, very easy to be acquired, namely, by the manual alphabet, as it is called; that is, the expression of letters by different positions of the fingers. This art is valuable on many accounts; in the first place, as being a very quick and ready means of communication; and secondly, as it is a method very generally understood and practised by other persons besides the deaf and dumb. This art of talking with the fingers is commonly learned at school, and is easily retained, or recovered if lost. It furnishes a substitute for the pencil, or pen and ink, when the materials for writing are not at hand. The deaf and dumb, when properly instructed, can converse together with the utmost rapidity by this method; habit enables them to follow with the eye motions which, to others, would be too rapid for observation; they readily catch at the meaning of a word or question, before it is half spelt.

Dactylology.

In the common methods of indicating letters by the fingers, both hands are employed. Some persons have thought it would be attended with advantages, in point of convenience, to contrive a manual alphabet that would require the use of one hand only. Periere claims the invention of this method, to which he has given the pompous name of *Dactylology*, a term which the Abbé de l'Epée proposes to change to *Dactylolaly*. It appears, from a book published near two centuries ago, in which are engravings of different positions of the fingers of one hand, representing the several letters, that this method was well known at that time in Spain. Sicard, in his *Cours d'Instruction d'un Sourd-muet de naissance*, has given a plate of the manual alphabet employed in his institution. It would appear, however, to be a considerable objection to this single-handed alphabet, that it is not in general use among other persons, so that it cannot assist the deaf and dumb beyond the precincts of his school. These alphabets are, however, so easily acquired, that it must always be worth while for him to learn them both.

Aërial Writing.

There is yet another mode of visible intercourse, still quicker in its operation than the former, and which it may occasionally be very convenient to employ. It is that of indicating the forms of the letters by the point of the finger moved in the air, constituting, as it were, an aërial writing, which, by a little use, is quickly followed with the eye. It must be recollected that, to a spectator, who stands before us, the writing would appear reversed, if traced in the ordinary manner. This must be remedied by the letters being written in a reversed form, a method which may readily be acquired by practising before a looking-glass. If the person to whom we addressed ourselves were behind us, there would evidently be no necessity for this artifice; since the motions of the fingers would be seen by him in the same aspect as by ourselves. By means somewhat similar, namely, by tracing the letters with the finger on any part of the body, such as the hand or the back of the person with whom we wish to communicate, we may easily converse with him in the dark, a situation in which the deaf are peculiarly helpless.

Other parts of Speech.

Having proceeded thus far in our instructions, having taught our pupil the use and conventional meaning of words, having familiarized him by the various modes of writing and reading, with their visible appearances, and put him in possession of a copious vocabulary of the names of objects of common occurrence, we may be considered as having achieved the most difficult and certainly the most important part of our task. There yet, however, remains much to be done. Substantives are all that he at present knows; but the expression of thought and passion, the affirmation or denial of the relations between ideas, demand words of another class; or, as they are called, other parts of speech. The most natural order of proceeding would seem to be that of teaching him next the use of adjectives, and the relation in which they stand to substantives. A few examples of adjectives, denoting sensible properties of objects, such as those of colour and form, connected with substances that possess these properties, will very soon give them this knowledge, and enable them to apply these adjectives properly. The meaning of pronouns and of verbs are next to be pointed out, with their various modifications of person, number, and tense. All this should, in our opinion, be taught wholly by examples; for which purpose, short and simple sentences should be selected, of which the meaning may readily be conveyed, by the assistance of pantomimic language, and will soon be collected by the pupil himself, whose sagacity in observing the occasions on which such expressions are employed will lead him to the discovery by a natural process of induction.

A method proceeding on a diametrically opposite principle has been adopted by teachers of the first eminence on the Continent, who insist upon the necessity of teaching the deaf and dumb all the parts of speech one after another, with critical and philological precision, and in exact conformity with the order of the analysis of the different classes of words.

They appear to forget that, in the case of ordinary children, nature pursues a very different course. These learn their native language in a short period, without all the technical apparatus of the pedagogue. The study of the rules of grammar is, more especially, useful in teaching a new language to a person who is already conversant with his own. The business of the teacher is here, indeed, reduced chiefly to that of translation; while the substance is the same, it is the form only that is varied. Dr Watson is decidedly of opinion that, naming perceptions as they arise, without regard to metaphysical or grammatical distinctions, is the only sure and direct road to the acquisition of a language, by those who have only the natural language of gesture and feature to assist them in acquiring it. For, let it be strictly borne in mind, that the analogy between the naturally deaf, and those who hear, in learning a language, holds only with respect to the first language, or mother tongue. There can be very little in common with them, in the learning of a foreign or dead language, by the latter; for in this case, the mother tongue always serves to explain the terms of the language to be acquired, an advantage of which the deaf and dumb are totally deprived; and yet, if we compare the progress they make with that generally made by young scholars, in what are termed the learned languages, in the same length of time, we shall, for the most part, have reason to draw a conclusion in favour of the plan of following nature in teaching a language. It should not, however, be forgotten, that fairly to estimate the attainments of a deaf scholar, he should rather be compared, though subject to great disadvantages, to a child of an age equal to the length of time he has been under tuition, than to a youth, having all his faculties, who has been long at school.

While proceeding through the vocabulary of substantives, we are recommended by the same judicious author, in order to give variety to the lessons, to teach the pronouns, personal and demonstrative, &c. at suitable intervals, always making the learner write the words with his own hand. Then the verbs *to be*, *to have*, and the other auxiliaries, are to be learned or varied according to third persons, joined to nominative cases, as, *I am*, *he has*, &c. The meaning of all these is learned by application in examples. When he says *I*, he points to himself; when he says *you*, he points to the person teaching him; *he*, to a third person, &c. Nothing is more obvious to the eye than number, as a property of things; we, therefore, easily learn to count *one*, *two*, *three*, &c.

These preliminaries settled, we proceed to the construction of short sentences, without learning the rules of syntax. Thus, for instance, we may say, *this is my pen; that is your pen; that is his pen; these are our pens*, &c. *I have one body; I have two hands*, &c. showing the meaning, by pointing out the objects and their relations already perceived by and familiar to the learner, though he could not express them. By way of practice, he is taught to change the substantive, till he can himself give examples, and rightly apply all the words in such sentences, which, in general, he is not a little proud to do. Examples might be multiplied indefinitely in the application of each of the parts of speech, but enough have already been shown in illustration of the general principle of the process. In all cases, examples should be furnished to the learner, till the effect intended be produced on his mind; that is, till it appears by examples given by himself, that he rightly applies the word intended to be illustrated. These exercises should be introduced as reliefs to the less amusing, but, in the first instance, more important business of learning the vocabulary.

Employment of artificial Signs.

The system of instruction we have already alluded to, as opposed to the simple process now detailed, is founded upon the employment of a peculiar medium of communication between the teacher and his pupils. This medium, totally different and independent of ordinary language, is formed by a set of artificial signs for the expression of ideas, consisting, not of words, but of certain gestures assumed by convention as the representative of those ideas. These signs may, indeed, be considered as being virtually words, though wearing a different form. They in fact perform to the deaf all the functions of words, since every word in the language is represented in this system by its peculiar and appropriate gesture. In instructing the deaf and dumb according to this method, care is taken that, on their learning the meaning of any written word, the particular gesticulation appropriated to it shall be learned in conjunction with the word. The Abbé de l'Epée, the original contriver of this system, which has been adopted and extended by his successor, the Abbé Sicard, gives the following account of the circumstances which first turned his attention to the subject, and paved the way to the invention:

Two sisters, both deaf and dumb, resided at Paris in a street opposite to the Society entitled *Les Pères de la Chrétienne*. Father Fanin, one of the associates of that community, had attempted, but in a way not sufficiently methodical, to supply the deficiencies of instruction to which the loss of the faculties of hearing and of speech had subjected them; but he was unfortunately carried off by a premature death, before his labour had rewarded him with any degree of success. The two sisters, as well as their mother, were inconsolable for the loss they had suffered; when a fortunate accident introduced to them a person eminently qualified to fill the place of him they mourned for. The Abbé de l'Epée had occasion to call at their house. The mother was out; and while he was waiting her return, he put some questions to the young ladies; but their eyes remained fixed on their work, and they gave no answer. In vain did he renew his questions; they were still silent. Not suspecting that the ears of those whom he was addressing were closed to all earthly sound, he was lost in conjecture at the insensibility they manifested; when the mother arrived, and the mystery was resolved. So strong was the impression produced by this incident, that his thoughts were, from that moment, bent upon devising means of restoring to those unhappy young women the faculties of speech, and the means of intellectual intercourse. After meditating long on the subject, it occurred to him that every language is

but an assemblage of signs, in the same manner as a series of drawings is a collection of figures, the representations of a multitude of objects. Gestures are also signs; and we may figure every thing by gestures, as we paint every thing by colours, or express every thing by words. Every object has a form, and every form is capable of being imitated. Actions strike our sight, and we are competent to delineate and describe them accurately by imitative gestures alone. Words are but conventional signs. Why should not gestures serve the very same purposes? Why may there not be framed a language of gestures, as there has been a language of words?

Full of these impressions, the Abbé was not long without revisiting the family who had inspired him with so much interest; it is easy to imagine the joy his presence gave them. He was eager to try the success of his newly invented imitative art. He began his drawings, his gesticulations, his writings, conceiving he had but to teach a new language; while, in fact, he had first to form minds wholly uncultivated. Severe were the toils and the difficulties, and bitter the disappointments he had to encounter in these first essays. He showed his pupils merely letters, which he taught them to imitate; but nothing like ideas could in this way ever reach their minds; the act of imitation had been purely mechanical. Even when the objects themselves, denoted by words, were pointed out, still no conception of the relation in which they stood to each other was formed; for written words were not images. It was not enough that the Abbé had invented gestures to correspond with every word in the language; the necessary medium of communication was still wanting; he had no fulcrum for his apparatus to rest upon; and he was moving in a world placed beyond the narrow sphere of their conceptions. He was striving to teach a foreign language by a grammar written in that very language, without reflecting that an idiom, the words and the syntax of which are alike unknown, cannot be taught but by the aid of a dialect with which it is capable of being compared. No such comparative grammar exists for those whose ideas are limited to what may be suggested by transient sensations, resulting from instinctive wants. In leading his pupils to write words as signs, he was endeavouring to lead them to what they did not know, by setting out from what was equally unknown. He succeeded, it is true, in enabling them to transcribe whole pages of the most abstract disquisitions by the intermedium of gestures; but these gestures, which they had mechanically associated with certain characters, conveyed to them no notions of the real signification of those characters; for, as in every language, words are but conventional signs, it is clear that, before their meaning could have been agreed upon, there must have existed some prior language mutually understood by the parties making the agreement.

Notwithstanding the radical and glaring defects of De l'Epée's method, which must have precluded it from ever being of the slightest utility to those who followed it, the ostentatious display of that kind of success he obtained, and which was of a nature particularly calculated to impose upon a superficial observer, excited the astonishment and applause of a host of spectators; and being seconded by the impulse of his religious zeal, and beneficent charity, soon raised him to a high degree of reputation. His fame spread itself all over Europe, and his lectures and exhibitions attracted every where crowds of enthusiastic admirers. There were not wanting persons, however, who saw through the delusion. At a public exhibition of the pupils of the Abbé Storck, who were taught according to this method at Vienna, Mr Nicolai, an Academician of Berlin, proposed to the Abbé to require one of his pupils to describe in writing the action he was about to perform. The challenge being accepted, the academician struck his breast with his hand, upon which the deaf and dumb boy immediately wrote the words, *hand*, *breast*. Mr Nicolai withdrew, satisfied with this proof of total failure. It was evident that, notwithstanding all this parade of learning, and their quickness in writing down any question, together with its answer, both had been equally dictated by their master, in the same language of gesture, but without any corresponding ideas, or the exertion of any intellectual faculty, except that of memory. They were utterly incapable of composing a single sentence of their own accord; and it was found, accordingly, that their spontaneous answers to the questions asked them were limited to the monosyllables *yes* and *no*, of which it is even doubtful whether they fully understood the meaning. It is more easy to conceive than to describe the disappointment which the parents must have felt at the discovery of the real ignorance of their children after so many years of instruction, and after the brilliant manner in which they acquitted themselves in their public probations. The secret is, indeed, betrayed in some letters of the Abbé de l'Epée, published by Sicard, in a note to the work already referred to, in which he avows that his views of education were limited to the mechanical qualifications necessary to enable his pupils to perform their parts in a public exhibition, namely, that of writing words upon certain gestures being made to them, without the least intelligence of their import, and of course without the power of employing these words, either as instruments of thought, or as vehicles of meaning.

The Abbé Sicard, who had been for some time the assistant, and was afterwards the successor of De l'Epée, while he retained the system of artificial signs contrived by the latter, soon discovered that the intellectual education of his pupils should be the chief object of his efforts, and, in the pursuit of this object, struck out for himself a new path. An opportunity soon occurred for the developement of his plan, by his appointment as teacher to a school which had been recently established at Bordeaux, by the Archbishop M. Champion de Cicé; and among the first pupils presented to him for admission, was a boy and his sister, belonging to a numerous and indigent family, of whom five were deaf and dumb. They lived in an obscure cottage, in a remote part of the country; and the sole occupation of John Massieu, the name of the boy, had been to tend his father's flock of sheep, amidst heaths and forests; and whatever habits he had contracted were those of a savage life.

On being brought to Bordeaux, for the purpose, as he thought, of looking after other flocks, his astonishment and alarm at the new objects he beheld were extreme. His suspicions were awakened by every look directed towards him, and he shrunk from all intercourse with those who sought his confidence. His dull and vacant countenance, his timid and embarrassed air, his frigid and sullen reserve, all denoted a being unsusceptible of education. By judicious management, the prospect brightened; his faculties were developed; his intellectual powers were gradually excited and exercised; his capacity for receiving instruction expanded, and he made rapid strides in the acquisition of every kind of knowledge. He is at present distinguished by his intelligenee, acuteness, and general information; and is not only conversant with literature, but expresses himself with facility, clearness, and elegance. Sicard has detailed in his work the several steps of his instruction, as a model of his general method; of which, however, after what has been already said, a short notice only will be sufficient.

Methods used by Sicard.

The object of his first lessons is to teach his pupil the relation between the names of objects and the objects themselves; the analysis of words into the letters of the alphabet; and the particular gesture which he is to attach to each word as its distinctive sign. He then explains the meaning of collective words, as distinguished from those denoting individual objects, or parts of objects. Thence, he proceeds to general terms, applicable in common to a number of individuals, and to generic names comprehending a number of species; and lastly, ascends to the most general and abstract words, such as *being*, *thing*, *object*. The qualities, which are expressions of the accidents, variations, and modifications of objects, and are denoted by adjectives, are next taught. He endeavours to make his pupil conceive these qualities, in the first place, as inherent in the objects themselves, and next as being capable of being detached, by a mental operation, from such objects, though, in fact, they have no existence, but as united with them. We shall here give a specimen of the contrivances he has recourse to, in assisting his pupils to understand such abstract conceptions. Taking seven pieces of paper, each white on one side, and coloured on the other with one of the primitive colours, he places them on a table, before a black board, with their white sides uppermost. He then writes the word PAPER on the board, leaving sufficient intervals between the letters for the insertion of other letters. Then turning the sheet painted blue, so that the coloured side is now uppermost, he writes the word BLUE between the letters of the former word, but in smaller characters, thus,

P B A L P U E E R.

The same thing is done successively with regard to the other sheets of paper, inserting the name of its respective colour between the letters of the word PAPER, which is repeated for that purpose. This being finished, the blue sheet is again turned down, so that its white side is presented; upon which, the smaller letters, composing the word *blue*, are effaced, while the other letters, P, A, P, E, R, are allowed to remain. By this process the pupil is taught to consider the quality as part of the object, or as inherent in it. In like manner, he proceeds with other adjectives, such as *round*, *square*, &c. expressing the form of objects; writing them in the intervals of the letters composing the name of the respective objects; effacing them, and substituting others, according as the form of the object is varied.

In order to lead his pupil to form the abstraction of the quality thus expressed, that is, to the use of the adjective as a separate word ready to be applied to different substantives, he employs the following diagram, the different lines of which he traces before his eyes, in order to point out the steps by which he is to arrive at this abstraction.

```
P B A L P U E E R
 .   .   .   .
P · A · P · E · R
 .   .   .   .
  B   L   U   E
 .   .   .   .
P · A · P · E · R      B L U E
 .   .   .   .         . . . .
 . . . . . . . . . . . . . . .
     .   .   .           . . .
     . . . . . . . . . . . . .
         .   .             . .
         . . . . . . . . . . .
             .               .
             . . . . . . . . .
```

The two words, thus obtained separate, he afterwards unites by a connecting line, thus,

PAPER — BLUE

The next step, in order to form this into a complete sentence, is to insert the word *is*, instead of the line; of which line it may accordingly be regarded as the substitute and representation.

PAPER IS BLUE.

By thus making his pupils understand the nature of a verb, and afterwards teaching them that the verb can express either an existence or an action, *past*, *present*, or *future*, he leads them to the system of conjugation, and to all the shades of tenses adopted in various languages. The various significations and inflections of pronouns, with the corresponding affections of verbs, in regard to number and person, are conveyed to the minds of the deaf and dumb, by contrivances very analogous to the preceding, and which need not be dwelt upon, after the example already given. They proceed upon the general principle of connecting together by lines the words, denoting the ideas, which are the component parts of other ideas, so as to express their union; and writing in the place where the lines unite, or in place of the other words in a similar diagram, the name of the compound idea. Another part of Sicard's system is the employment of a system of cyphers, written on the top of every word or member of a sentence, according to the office it performs in that sentence; by the help of which his pupils are better enabled to analyze it into its essential parts, distinguishing the name of the object, which is either acting or receiving an action, the verb and its regimen, direct, indirect, or circumstantial, and thus comprehending

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and displaying every part of speech. Thus he instructs his pupils in the science of universal grammar, applicable to the primitive expressions of signs, as well as to all spoken and written languages.

Objections to his System.

Of the system of artificial signs, which is represented by Sicard as the essential groundwork of all this knowledge, and as the principal means of imparting it, there is much room to doubt the practical advantage. To the praise of ingenuity its author has certainly a claim; but it can scarcely be regarded as any approach to a philosophical language, being as much founded in metaphor and distant analogies as any existing language. With speech it cannot bear any comparison in point of quickness, for the modulations of the voice are capable of being executed with a rapidity far exceeding that of gestures. There is, besides, hardly any mode of fixing the idea of a gesture by some visible type, as there is that of sound by writing, which serves at all times to renew the impression with perfect correctness. Hence the difficulty of forming a vocabulary of gestures, even to those already in possession of the use of written language, of which we must, of course, suppose our pupils ignorant. These gestures, it is pretended, are engrafted on the natural language of pantomime; but this natural language can carry us but a very little way in the expression of thought. Every action, the visible part of which can be imitated by gesture, admits easily of being so expressed; as the action of eating, by lifting the hand to the mouth, followed by the motion of the jaws; and of sleeping, by closing the eyes and reclining the head. The expression of different passions, of approbation, or disapprobation, of surprise, of inquiry, &c. may all be signified very intelligibly by modifications of the countenance. It is in this simple manner, observes Dr Watson, that two or more deaf and dumb persons are enabled to hold instant converse with each other, though brought together for the first time from the most distant parts. Thus far these signs may be termed *natural;* but the naturally deaf do not stop here with this language of pantomime. When they are fortunate enough to meet with attentive companions, especially where two or more deaf persons happen to be brought up together, it is astonishing what approaches they will make towards the construction of an artificial language. By an arbitrary sign, fixed by common consent, or accidentally hit upon, they will designate a person or a thing, and only that particular person or thing, by this sign; which is ever after used by them as a proper name. It is remarkable, that, although in the first instances of inventing or applying these sign-names, if they may be so called, they are guided by some prominent, but, perhaps, by no means permanently distinguishing mark, such as (in the case of a person) a particular article of dress being worn,—the first time of becoming acquainted,—an accidental wound, though it leave no scar,—a peculiarity of manner, &c.—yet, after having fixed upon it, they never vary, notwithstanding the peculiarity that guided their choice should have long ceased to be observable in the person of the individual they have so designated. Nor will they fix upon the same sign for another of their acquaintance, though, at the time of first meeting him, he may have the same mark about him, which they had used to specify a former person. This fully proves that they regard the sign merely as a proper name; and they receive it as such from one another, without inquiry as to its origin. Thus, supposing a person, the first time he should be particularly taken notice of by one who is deaf and dumb, had accidentally cut his face, and wore a patch, it is a hundred to one that this would, from henceforward, be his distinguishing mark, unless some one else of the deaf person's acquaintance had already been so distinguished. The wound might be cured, and the patch removed; but the deaf person would uniformly put the end of his finger to the part of the person's face where the patch had been worn, when he wanted to point him out. And lest those to whom he might be desirous of afterwards communicating something concerning this person, should not comprehend him, he will not fail to introduce him to them, by repeatedly pointing to him, and then to the mark by which he means to describe him, till he thinks he has sufficiently engaged their attention. By similar contrivances, places and things, as well as persons, nay, even qualities and circumstances, are distinguished by the deaf, in an astonishing manner. To attempt in words a description of those signs would be endless, because they are various as the fancies and circumstances of their inventors. Yet being grafted on the parent stock of natural and universal signs, they may, in some measure, be regarded as different dialects of the same language.

Hence every one who undertakes the arduous task of teaching the deaf and dumb, should sedulously turn his attention to the study of that language termed *natural*, where it consists of gesture and feature, in order to enable him to comprehend, as far as possible, the signs of his scholars, which at first, more or less, differ from one another, as they more or less resemble those signs universally intelligible. Of how much importance it is to the teacher to understand these signs, will readily be apprehended, if any one will attempt, either to teach or learn a language, without having another, common to master and scholar. But, never let any thing so chimerical be thought of as an attempt to turn master to the deaf and dumb, in the art of forming signs. What should we expect from an European, who should undertake to teach his own regular, copious, and polished language to a South Sea Islander, who was henceforward to live among Europeans, and whose scanty vocabulary extended only to a very few words, barely sufficient to enable him to express, in a rude manner, what was required by the uniformity of his condition and the paucity of his thoughts? Should we suspect that the teacher would set about new modelling, methodizing, and enlarging this rude and imperfect language, as the readiest method of making the islander acquainted with the European tongue; especially when this new modelled language, after all the pains bestowed in forming and teaching it, could be of no manner of use but to assist the intercourse between these two persons? If this supposition appear ridiculous, how much more fanciful and useless is an attempt to methodize signs, for the in-

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struction of the deaf and dumb! Would it not be a more natural and rational mode of procedure for the teacher to begin by watching the objects and occasions to which the scholar applied the words of his barbarous speech; that by knowing these he might gradually substitute the words of the language to be taught; using the *former* only as an introduction to the latter? It should never be lost sight of, that deaf people are not educated to live always among persons in their own unfortunate situation. Were this the case, indeed, an artificial language of methodized signs might be of important use. But as they are intended to mix with their fellow beings, in social habits and necessary avocations, we have to open a channel to this intercourse; and this cannot be done so effectually by any other means, as by teaching them the language of the country where they reside.

To these judicious remarks of Dr Watson may be added the consideration, that our object in educating the deaf and dumb, is not so much to make them acute grammarians and subtile metaphysicians, as to render them useful members of society. Experience shows, that the more simple and ordinary modes of instruction will effect this latter purpose in less time, and with better success, than the former can be accomplished by the complex and elaborate system we have been considering.

Teaching the Deaf to speak.

Another most important branch of the education of the deaf and dumb remains to be considered, namely, the teaching them to speak, and to understand what is spoken by others, by observing the motion of their lips. That any person, without the guidance of the sense of hearing, should be enabled, merely by studying the position and action of the organs of voice, to utter articulate sounds with any tolerable perfection, would at first view appear scarcely credible. Experience, however, has shown, that the task, though laborious and tedious, is not attended with this extreme difficulty. Even the earliest attempts of those who have cultivated this art, appear to have been as completely successful as those of modern instructors. Great patience and perseverance would seem to be the chief qualities necessary to ensure success in ordinary cases. When we talk of success, however, it must be stated, that a wide difference must ever remain perceptible between the speech of the deaf and of those who hear. This artificial speech is evidently laborious and constrained, conveying frequently the idea of pain as well as of effort. As it cannot be regulated by the ear of the speaker, it is often too loud, and generally monotonous, harsh, and discordant. It is often, from this cause, scarcely intelligible, except to those who are accustomed to its tones. It is only, indeed, to such as are in habits of daily intercourse with them, that it fully answers the purpose for which that gift was bestowed on man, namely, the communication of thought.

It may, indeed, be a matter of some doubt, whether these advantages, limited as they must necessarily be, are a sufficient compensation for the time and labour consumed in their attainment; and which might perhaps be better employed. The decision of this question, as far as it concerns any particular individual, must, however, depend in a great measure on peculiar circumstances, such as his condition in life, and future destination. The Abbé Sicard, perhaps from a predilection for the method of artificial signs, renounced the pursuit of this object, as not worth the pains, and as interfering with his general plan. In Great Britain this art has been at all times cultivated with more assiduity and with greater success than on the continent. The experience of Dr Watson is decidedly in favour of its utility. In support of his opinion he states one argument, which must doubtless be allowed to have considerable weight. The more numerous are the means of association, he justly observes, the more perfect will be the recollection; or, in other terms, the more frequent the recurrence of words, and their corresponding ideas to the mind. Thus, persons who can hear, speak, read, and write, retain a discourse much better, and have far greater facility in expressing themselves, than persons who possess only two of these faculties; that is, illiterate persons, who can hear and speak, but who cannot read nor write. Now, as deaf and dumb persons, educated without articulation, can only have two of the means, viz. the third and fourth; that is, the impressions made upon the eye by characters, and the action of the hand in writing; can it be questioned that we render them an essential service by adding the actions of the organs of speech; a very powerful auxiliary, since by it words become, as it were, a part of ourselves, and more immediately affect us? In learning the pronunciation of the letters, a very important operation is going on in the mind of a deaf person; namely, the association, in the memory and understanding, of the figures of written or printed characters, with certain movements or actions of the organs of speech. The very habit of regarding the one as the representative of the other, paves the way for considering combinations of those actions or characters, as the signs of things or of ideas; that is, significant *words*, written or articulate. We, who hear, consider words chiefly as *sounds;* the deaf, who have learnt to speak, consider them rather as actions proceeding from themselves. And this gives language, to them, a sort of tangible property, which is of vast importance, both as respects its retention in the memory, and as it respects one of its most important uses, the excitation of ideas in their own minds. On this account, the time, the labour, and attention, necessary to acquire articulate speech, by those who are dumb, through want of hearing, would be well bestowed, even if their speech were not intelligible to others. Deaf persons, having learnt to speak, are frequently overheard speaking softly to themselves; that is, rehearsing words or sentences, either for the purpose of better remembering them, or of framing such expressions as they think will best convey their ideas.

Methods for that purpose.

The act of speaking is evidently an operation purely mechanical: and the instruments by which it is performed are the lungs, windpipe, and larynx, the tongue, nostrils, lips, and the various parts of the mouth. The lungs supply breath like the bellows to a musical organ: and the shortening or elongation of the trachea produce the varieties of grave and sharp

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tones in the voice, though these tones are again modulated by the movements of the parts of the larynx, which are disposed so as to expand or contract the aperture of the glottis. The articulation of syllables, or the formation of the different letters, begins after the breath has been emitted through the larynx, and is accomplished by means of the mere external organs of speech, that is, the mouth, nostrils, tongue, teeth, and lips.

Pronunciation of the Vowels.

The following is the process employed by Dr Watson in teaching the pronunciation of the vowels. "The first step," he says, "is to obtain a clear and distinct sound from the throat (in a voice tolerably well pitched; for this is our *materia loquelæ*), as, of *a*, in the word *wall*, &c. To effect this, and to habituate the pupil to associate the sound which he is learning to form, with the figure of the letter which is to be its representative, this is distinctly traced upon paper, or any convenient tablet, and he is made to look at it for a minute or two: he then, if of acute intellect, will look up, with some anxiety in his countenance, as if he would ask what he is to do with it. The sound is then slowly and fully pronounced, and the learner made to observe, by his eyes, the position and motion of the external organs of speech, and to feel the astriction of the muscles of the larynx, by placing his finger upon the throat, carefully making him perceive the difference to be felt there between sound and silence. Having made these observations for a minute or two, he will seldom hesitate to attempt an imitation of what he has been observing; and that, for the most part, successfully. When the contrary is the case, nothing more is necessary than patient and good-natured perseverance; for if he perceive that his failure has excited chagrin or disappointment in his teacher, he will make another effort with great reluctance. The sound once acquired, must be practised sufficiently to avoid any danger of losing it; for the greatest care must be taken, all throughout his progress, never to proceed to a new sound till the preceding has become familiar, and unattended with doubt as to the manner of producing it. A contrary practice would lead to endless vexation. A principal requisite is to keep the learner in good-humour, and to make him think that he is doing well beyond expectation; nothing is more discouraging than to put him back." In the same manner does he proceed to the simple sounds of the other vowels, and then to the consonants.

Of the Consonants.

By the powers of the consonants, are meant the positions and actions of the several organs employed in their formation, without the addition of any distinct vocal sound. For although frequent mention will be made of sound in the throat, in their formation, it is to be understood as so confined by the position of the organs, as not to partake of any of the sounds represented by the vowels.

By closing the lips,—sounding gently in the throat,—forcing them asunder by the emission of the breath,—and carefully avoiding to let any of it pass through the nose,—we have the power of B. After the same manner is formed the power of P, but without sound in the throat. M requires the lips to be closed,—the sound made in the throat,—and the breath suffered to escape through the nose.

The power of C, or what is called its hard sound, that is, the sound of K, is formed by raising the back part of the tongue to the roof of the mouth, near the uvula, and forcing it away again rather quickly, by an emission of the breath, without sound in the throat. G has the same formation, with the addition of sound in the throat.

The power of D is produced, by placing the tip of the tongue against the two rows of teeth, which are to be quite, or nearly shut,—sounding in the throat,—emitting the breath in removing the tongue from the teeth,—and, at the same time, opening them a little. T has the same formation, only without sound in the throat.

By placing the upper row of teeth upon the under lip, and gently emitting the breath, without sound in the throat, we have the power of F. V has the same formation, with the addition of sound in the throat.

H is a mere emission of breath, with the mouth a little open.

J has the power of D and SH combined.

L is formed by raising the point of the tongue to the roof of the mouth, near the upper teeth,—sounding in the throat,—and suffering the breath to escape freely on each side of the tongue.

The power of N is formed by raising and pressing the tongue to the palate, with the whole of its upper surface, so that no breath may escape but through the nose,—the lips being kept open, and a gentle sound being made in the throat.

For Q, join K and W.

R is variously formed; but the surest and easiest way of teaching its power to a deaf person, is by elevating the fore part of the tongue to the palate, and, with the assistance of the breath, causing a vibratory motion of it, accompanied with a gentle sound in the throat.

In forming S, place the tip of the tongue just below the under teeth, raise the sides of it to the palate, leaving a small aperture in the middle, through which the breath is to be forced, without sound in the throat, which will be intercepted by the teeth being shut, and form the hissing sound required. Z requires the same position of the organs, with the addition of sound in the throat.

X is compounded of K and S.

CH is compounded of the powers of T and SH.

SH has a power nearly resembling to that of S, and requires a position of the organs something similar, except that the tip of the tongue must be drawn back, instead of touching the gums and teeth; and the current of the breath emitted must be intercepted by the under teeth only in part; the rest must be suffered to escape between the rows of teeth, which must be a little opened for that purpose.

TH requires the tongue to be a little advanced between the two rows of teeth, and the breath emitted between it and the upper row, which must, nevertheless, be nearly in contact with it; this will produce the sound of TH, as heard in the word *think*. It has another power, requiring precisely the same

position of the organs, but with the addition of sound in the throat, heard in the word *this*, &c.

NG represents a strong nasal sound; to form it the tongue is drawn back and raised to the roof of the mouth, towards the uvula,—a sound made in the throat, and forced through the nose.

Syllables.

It is evident, that when the power of a consonant is acquired, it needs only to be combined with the vowels to form syllables; as *ba*, *ab*, &c. These the pupil pronounces almost at sight, as he does also *bab*, and any other combination of a vowel and a consonant, or consonants, if well-grounded in the foregoing formations of them. From the easiest combinations we proceed to the most complex, and by practice acquire a readiness in pronouncing the longest polysyllables.

While acquiring the faculty of speaking, the deaf and dumb imperceptibly learn to distinguish by the eye the words spoken by others. "It is truly astonishing," says Dr Watson, "and would hardly be credited by any one who had not seen it, how readily deaf persons, who have themselves been taught to speak, catch words, and even long sentences, from the mouths of those who address them. Yet, in this sort of conversation, it is indispensable that the speech should be immediately directed to the *spectator* (we must not call him *auditor*), who must have an opportunity of observing every motion of the muscles (as far as these can be seen externally) and countenance, in order to make out the discourse. On this account, it is impossible for a deaf person to understand the conversation of a mixed company,—a discourse from the pulpit,—or harangue to an assembly, where the speaker does not immediately address him."

Course of Instructions.

After the sketch we have thus given of the principles on which the different departments of the education of the deaf and dumb should be conducted, it only remains for us to consider the best order in which we should proceed with their lessons and studies, and the period within which we may reasonably expect they are to be completed. In giving directions with this view, we shall still take Dr Watson as our guide.

Schools for the deaf and dumb, in which a great number are instructed at the same time, afford peculiar advantages to the teacher, and are very favourable to the proficiency of the scholars. By associating with others, who, being equally deprived of hearing, are on a level with regard to the difficulties to be surmounted, they are relieved from the continual sense of inferiority which oppresses and disheartens the deaf child when placed in the midst of those who have the perfect use of all their senses; and the influence of example, and a spirit of emulation, will operate with due force in exciting them to intellectual exertions. Dr Watson finds, by experience, that one deaf person may be employed to teach another with the happiest effect. So much so, that when he happens to be, for the moment, at a loss to make one of slow apprehension understand a lesson, he turns him over to one of his schoolfellows who has learnt it; and never without advantage to both. For it is with the deaf, as with every one, that we ourselves learn best by endeavouring to teach others.

The acquisition of the pronunciation of letters, of syllables, and of words, with their correct orthography, contained in the vocabulary already described, together with such additional exercises as will most obviously exemplify the application and meaning of the connecting parts of speech, will be sufficient occupation to the pupil during the first year of his attendance upon the school; and when the capacity is good, great progress is usually made in these particulars during this period. He is then prepared for longer exercises, and for the application of the words he has learnt. in the construction of longer sentences; to which he, of course, requires to be led on by easy and familiar examples. A sort of colloquy, or dialogue, must be entered into with him. The questions, at first, must be all on the teacher's part, and the answers must be formed for the learner, in the most obvious words and phrases that will convey his ideas, in strict conformity to which they must constantly be framed. Due attention being paid by learner and teacher, the good effects of this method will presently appear. The latter will soon be agreeably surprised by his scholar changing parts with him, and becoming, in his turn, the interrogator; and that, too, in a way that will show he practically understands analogy.

It will be useful to set aside certain stated periods, as once or twice in a week, for the repetition of words already learnt; taking care to see minutely, that correct ideas are annexed to each. When the whole of the words in the select vocabulary,—substantives, verbs, and adjectives, have been gone through several times, and the reader can correctly spell, speak, and point them out (if the names of things engraved), or show their signification by his signs (if the names of actions, or qualities, &c.), then he is to enter upon a work as yet altogether new to him. He is to go over his vocabulary again, and to learn a short definition of each word; that is, to tell the meaning of words by words. This employment is prescribed, not because he will better understand the words in his vocabulary by being taught to define them, but because an opportunity is thus afforded of enlarging it, by the introduction of synonymous words, and words that are defined in some way from those we are defining; and these new words enable us to explain others. So that, by this means, and by our colloquial exercises, our vocabulary is daily and almost imperceptibly enlarging. This is strictly analogous to the manner of acquiring a first language by those who hear. The conjugation of verbs is, in the mean time, to be carefully attended to; and one example, at least, through all the moods, tenses, and persons, should now be performed every morning, till the pupil can write any person of any mood or tense required.

By this time, probably about the third year of the learner's progress, supposing in him the requisite attention and capacity, it will be proper and necessary to begin the reading of printed books, for the sake of profiting by the information they contain. As

far as the mere act of reading is concerned, we have no new difficulty to surmount, for all our exercises and lessons have, in fact, been read as well as written by the learner. The difference between printed characters and those used in writing has, of course, not been unobserved. What constitutes the chief impediment to making sense of what is met with in books, is the promiscuous use of words, without regard to our selections. What is to be done when we meet with a word which we have never seen before? Precisely that which is done with all children under similar circumstancs,—explain it by the substitution of a word, of which the meaning is known, if it can be done; if not, pass it over till a favourable opportunity shall occur to show its meaning, by an example. If no such opportunity ever occur, then can the meaning of the word be of no great moment to the learner.

In order to discover the progress he has made, and is daily making, and to assist him in the composition of sentences (the expression of his thoughts in writing), he is now required, every day, to furnish a certain number of lines, according to his capacity, from his own ideas. He is at liberty to choose his subject: he may relate what he has seen in his walk, —in his play ground,—or he may unfold the stores of his memory, relative to more distant places and periods. He may ask questions, &c. His rude essays at expression are often curious, and require some skill in the language of pantomime, to discover their meaning by his own explanations. This attained, it is put into correct, but easy language; he commits it to his memory thus corrected; and goes to work again, "at his leisure hour in the evening" for the next day, generally profiting considerably by the alterations it was necessary to make in his preceding essay We have now a new channel of communication opened; and the knowledge of the meaning of words, and their use in the construction of sentences, which we have already acquired, may be carried to almost any given degree of perfection and extension. Frequent conversation and intercourse, by the words of the language he has learnt, is of the very utmost importance to a deaf person, especially if he should have but little leisure or inclination for reading, as the means of extending his knowledge of language, and of enlarging his conception of things; and as the means of retaining what he has acquired. Every one will readily perceive this, who considers how easily a foreign or dead language is lost, for want of reading, writing, or speaking in it.

Institutions for Instructing the Deaf and Dumb.

British.

The "Asylum for Educating the Deaf and Dumb Children of the Poor," established in the immediate vininity of London, by private subscriptions in the year 1792, is under the very able superintendence of Dr Joseph Watson, to whose excellent work we have been so much indebted. No child is admitted on the charitable foundation under the age of nine years. This age was not fixed upon, from any idea that it was the earliest at which regular education could be advantageously begun. But, *five* years being deemed, generally speaking, sufficient to accomplish that course of instruction thought most essential to such children, destined to earn their bread by the labour of their hands; and *fourteen* being the earliest age at which they could be apprenticed, it was judged best, for the economical purposes of the Institution, not to receive them before the age of nine years. That he may not be misapprehended, Dr Watson afterwards states precisely what he understands by an education most essential to deaf children of the class mentioned. "I deem it essential," says he, "that they should have such a knowledge of language as to enable them to express their ideas on common occasions: to understand the commands or directions it may be necessary to give them in ordinary cases, &c.; to read with intelligence the precepts, the examples, and the promises, which are contained in the Scriptures, particularly the New Testament: that they should write a good hand, spell correctly the words they use, and understand the principal rules of arithmetic. When I say that these acquirements may be attained in *five years*, I mean to state that as the shortest time; even where the capacity of the learner is good. Where the mind is intended to be enlarged by a system of general information and science, a proportionably longer time must necessarily be required for its accomplishment."

An institution of a similar kind has recently been established at Birmingham, to which Mr Thomas Braidwood, who conducted a private school for the same object at Hackney, has been appointed teacher. Though the original design did not go beyond that of a day-school, for the more immediate instruction of such objects as might be found in Birmingham, yet since, by the zealous exertions of a number of its friends, the charity has attracted a more general attention, a liberal subscription was raised for providing a building for the reception of children from greater distances. This building was completed and first opened in January 1815, and is competent to contain forty children.

A society was instituted in Edinburgh, in June 1810, for the education of deaf and dumb children. The first teacher was Mr John Braidwood, a member of the family which has done so much for the instruction of these interesting objects. On his removal, a short time afterwards, Mr Robert Kinniburgh was appointed teacher of the school; and continues to discharge that duty with great ability and success. The number of his pupils at present is fifty. (1818.) All of them are boarded in the society's house, where they are taught reading, writing, and arithmetic; and are carefully instructed in the principles of the Christian religion: they are also instructed to express their wants and ideas in articulate speech. No child is admitted under nine, or above fourteen years of age. Six years are required for completing their education. Besides the above-mentioned branches of education, which the whole pupils are taught in common; those who are destined to particular trades and occupations, receive the appropriate instruction to qualify them for these. The female pupils are taught needle-work; and those of an inferior station are qualified by the proper instruction for domestic service. A certain number of the boys are brought up in the institution to the trade of shoemaking; and some profit now arises from the sale of articles manufactured by them. A number of the

pupils have already completed their education, and have left the school, furnished, with all the means of profitable occupation, and endowed with all the privileges of rational and moral beings. One of them, a most meritorious youth, named Joseph Turner, is retained in the school as an assistant teacher; and in that capacity is found extremely useful. His participation of the common infirmities of the pupils, gives a peculiar value as well as interest to his instructions.

The pupils undergo a public examination once a year; and never fail to gratify and astonish crowded audiences, by their remarkable promptitude in defining abstract terms, by their minute acquaintance with the facts and doctrines of the Christian religion, and by the excellence of their compositions.

The institution was established, and is wholly supported, by private subscription, and by the aids contributed by auxiliary societies in some of the other towns in Scotland. Its expence, for the last year, (1817) was about L. 1000. The charge for each pupil, for education and board, is L. 20; of which the society pays the half, and in some instances the whole; when the parents or friends of the pupils are unable to contribute any part.

It has been ascertained, by the result of actual inquiries, that the number of deaf and dumb persons in Scotland is not less than 800. The directors of the society, therefore, are anxious to extend its sphere of usefulness, by interesting all parts of the country in its support; and of such support, we believe it to be fully as deserving as any similar institution in any part of the world.

Foreign Institutions.

Several institutions for similar objects have been formed on the continent. The Asylum for the Deaf and Dumb at Paris, which is under the management of the Abbé Sicard, has in view not only to enable them to communicate their ideas and to form their understanding, but also to qualify them to earn their subsistence. On quitting the asylum, they are all capable of following a trade or profession. Their apprenticeship begins on their first entering the institution, and is terminated with their instruction. This apprenticeship takes place under the inspection of ten masters, viz. 1. a printer; 2. an engraver of precious stones; 3. a copper-plate engraver; 4. a drawing master; 5. a turner; 6. a Mosaic artist; 7. a tailor; 8. a shoemaker; 9. a cabinet maker; 10. a gardener. All these masters reside in the asylum, and receive their board and a salary. The public exercises, which the Abbé Sicard gives once or twice a month, are meant to excite emulation among the pupils, to make the establishment known, to collect observations, and to inculcate his principles of the art of teaching, and to illustrate their success by exhibiting experimental proofs of the intelligence and knowledge of his pupils.

Several institutions formed upon the model of that at Paris have been established in Germany, Holland, Russia, and Sweden. In general, they do not attempt teaching the pupils to speak.

Works on this subject.

A Spanish Benedictine monk of the convent of Sahagan, in Spain, named Pedro de Ponce, who died in 1584, is the first person who is recorded to have instructed the deaf and dumb, and taught them to speak. He has, however, left no work upon the subject: though it is probable that the substance of his method is contained in a book of Bonet's, who was secretary to the constable of Castile, printed at Madrid in 1620, under the title of "*Reduction de las Letvas, y Arte pava ensenar à hablur los Mudos.*" The following is a catalogue of the principal works on this subject, or referring to it, that have since appeared, and which may be consulted for further information.

Philocophos, or the Deaf and Dumb Man's Friend: by Dr John Bulwer, 1648: also, by the same author, in 1644, *Chirologia, or the Natural Language of the Hand:* and *Chironomia, or the Art of Manual Rhetorique.*

Dr Wallace's *Grammatica Lingua Anglicana;* and a treatise prefixed to it, *De Loquela, sur de sonorum omnium loquetarium formatione.*

A letter from Dr Wallace to Mr Boyle in the *Philosophical Transactions* for July 1670; and another from the same, in the volume for 1698.

Helmet's *Alphabeti vere naturalis Hebraici brevissima Delineatio*, Salzburgh, 1657

In the *Philosophical Transactions* for January 1668, an account is given of a small tract published the preceding year by the same author, entitled *Alphabetum Naturæ.*

Dr Holder's *Elements of Speech, with an appendix concerning Persons Deaf and Dumb*, 1669.

Treatise concerning those that are born Deaf and Dumb. By George Sibscote, 1670.

G. Dalgarno's *Didascalocophus, or the Deaf and Dumb Man's Tutor*, 1680. See the article DALGARNO.

C. Amman's *Surdus Loquens*, 1692: and *Dissertatio de Loquela*, 1700.

The Mémoires Présentés à l'Academie Royale, 4to. Paris, 1768, contains a valuable memoir of Pereire.

Institution des Sourds et Muets, par la voie des Signes Methodiques; ouvrage qui contient le projet d'une Langue Universelle, par l'entremise des Signes naturels assujettis à une methode, Paris, 1776, an anonymous work of the Abbé de l'Epée. A new edition appeared in 1784, much altered, and with the title of *La véritable manière d'instruire les Sourds et Muets, confirmée par une longue expérience* This last work has been introduced into the *Encyclopédie Methodique, Arts et Métiers*, under the article *Muets et Sourds*, and was translated into English anonymously in 1801.

An Essay on the Method of Teaching the Deaf and Dumb to Speak, by Dr William Thornton, is to be found in the third volume of the *Transactious of the American Philosophical Society.* Philad. 1793.

Cours d'Instruction d'une Sourd-Muet de naissance, et qui peut être utile à l'Education de ceux qui entendent et qui partent. Par Roch-Ambroise Sicard, Paris, 1800. A second edition appeared in 1803.

Mémoire ou Considerations sur les Sourds-Muets de Naissance, et sur les moyens de donner l'ouie et la parole à ceux qui en sont susceptibles. Par U. R. T. le Bouvyer Desmourtiers, Paris, 1800.

Instruction of the Deaf and Dumb. By Joseph Watson, LL.D. 2 vols. 8vo. Lond. 1809.

Théorie des Signes pour l'Instruction des Sourds-Muets. Par R. A. Sicard, 2 tom. 8vo. Paris, 1808.

Recueil des Définitions et Réponses les plus remarquables, de Massieu et Clerc, Sourds-Muets, aux divers questions, qui leur ont été faites, dans les Séances Publiques, de M. l'Abbé Sicard, à Londres. Auquel on a joint l'Alphabet, Manuel des Sourds-Muets, le Discours d'Ouverture de M. l'Abbé Sicard, et une Lettre explicative de sa Méthode, par M. Laffon de Ladébat. *Avec Notes et une traduction Anglois*, par J. H. Sievrac. London, 1815.

Diderot, *Lettre sur les Sourds-Muets.*

This last mentioned author alludes to the possibility of a child being born at once deaf and blind, a possibility which has also been anticipated by the Abbé Sicard, in the preliminary discourse to his *Cours d'Instruction*, p. li. where he suggests different methods of instruction that might be attempted in circumstances so apparently hopeless. The first instance in which this deplorable combination of defects is recorded to have occurred in any individual, is mentioned by Dr Watson, in a quotation from the *Gentleman's Magazine* for November 1808, p. 1041. He also adds another example in the person of James Mitchell, whose history has of late excited so much interest, and has been narrated by the masterly pen of Mr Dugald Stewart, in a memoir published in the *Transactions of the Royal Society of Edinburgh*, Vol. VII. p. 70. Mr Wardrop, who performed upon him the operation of couching, has given us some valuable and interesting particulars of his case, in a separate work, entitled *History of James Mitchell, a Boy, born Blind and Deaf, with an Account of the Operation performed for the Recovery of his Sight.* Lond. 4to. 1813. In the 8th Volume of the *Transactions of the Royal Society of Edinburgh*, are to be found *Additional Communications respecting the Blind and Deaf Boy, James Mitchell*, by the late Dr John Gordon; a gentleman who had paid particular attention to the case of Mitchell, and from whom Mr Stewart acknowledges he received much of the information contained in his paper. This volume also contains a paper *on the Education of James Mitchell*, by Dr Dewar: and an additional communication from the same author on this subject.

(W.)

DECOMPOSITION, CHEMICAL.

Decomposition, Chemical.

WE propose, in this article, to give a short but comprehensive sketch of the methods at present employed by Chemists for the analysis or decomposition of the different substances subjected to their examination, and for ascertaining the constituents of chemical compounds.

History of this Branch of Science.

This very important branch of the science is quite modern. Bergman was the first who attempted to lay down rules for the analysis of minerals, in his treatise *De Minerarum Docimasia Humida*, first published in the year 1780; and, for the analysis of waters, in his treasise *De Analysi Aquarum*, first published in the year 1778. Many improvements were introduced into every branch of analysis by Bergman, Scheele, and Lavoisier. Klaproth greatly facilitated the analysis of minerals, by introducing the use of caustic potash. He devoted a long and laborious life to this department of chemistry, and reduced every part of it under regular formulas. His *Beitrage*, in six octavo volumes, published between the years 1795 and 1815, is still the best guide for every person who wishes to become a proficient in this essential department of chemistry. Vauquelin has also devoted a long and active life to chemical analyses. His researches have had a more extensive range than those of Klaproth, for he has not confined himself, like that chemist, to the mineral kingdom, but has devoted much of his time to the analysis of animal and vegetable substances. To him, also, we are indebted for a general formula for the analysis of minerals, which, though not quite adapted to the present state of the science, was of the most essential service when it appeared. It is to it that the writer of this article is in a great measure indebted for his first introduction to the practical knowledge of this subject. To Rose we owe the method of analyzing minerals containing an alkali, which is at present pursued. The introduction of the Atomic Theory formed a new era, in the precision with which chemical analyses were conducted. And Berzelius has given us the most ample collection of precise analytical experiments that have yet appeared. Gay-Lussac's doctrine of volumes has contributed no less essentially to the improvement of the analysis of gaseous bodies. Indeed, it is merely the atomic theory exhibited in another point of view, for there exists a very simple and obvious relation between the specific gravity of a gas and the weight of its atom.

But, in this article, which must, of necessity, be confined to a narrow space, it would be impossible to particularize all the numerous contributors to the improvement of Chemical Analysis. It may be sufficient to mention that the two latest treatises on this subject which we have seen are by Thenard and John. Thenard has devoted the whole of the last volume of his Chemistry, published in 1816, and consisting of 209 octavo pages, to a treatise on the *Art of Chemical Analysis.* His formulas are rather too brief to be a sufficient guide to those who are quite ignorant of the art. Yet his treatise possesses considerable merit, and was perused by the writer of this article with a good deal of interest, because it made him acquainted with the methods of analysis pursued by the French chemists, and put it in his power to compare them with those which he himself has been in the habit of practising. John's *Laboratorium* is a much more extensive, and apparently a more complete treatise than that of Thenard. But the writer of this article is not entitled

to give an opinion respecting it, as he had it in his possession only for a few hours, and could do nothing more than glance at the general plan.

Chemical substances are very numerous, as they consist of all the bodies to be found on the globe. They may, however, be arranged under certain grand heads; because the mode of analysis followed is analogous for every substance included under the same head; but it differs materially when we proceed from the examination of substances belonging to one head to those of another. The analyses are conducted by means of certain substances which have a chemical action upon the bodies to be subjected to examination. If we were to compose a complete treatise on this subject, it would be necessary to enumerate all these reagents, to describe their properties, and to point out the mode of obtaining them in a state of purity. But this could not be done without occupying a very considerable space; and would, besides, be a repetition of many things which have been already detailed at sufficient length in the body of the *Encyclopædia*, and even in some articles of this *Supplement*. We shall therefore take it for granted, that the readers of this article are already acquainted with the names and the general properties of the different chemical substances which we shall have occasion to mention; and that, if they reduce any of our rules to practice, they will take care to purchase the requisite articles in a state of sufficient purity.

We shall divide this article into eight chapters, in which we shall treat successively of the following classes of bodies: 1. Gases; 2. Salts; 3. Mineral Waters; 4. Metals and their alloys; 5. Stones; 6. Ores; 7. Vegetable Substances; 8. Animal Substances.

CHAP. I.—Of Gases.

The gases at present known, and likely to be the subject of chemical investigation, amount to about 21. Several of these are absorbed by water in such great quantity, that they can be examined only over mercury; but the others not being sensibly absorbed by water, or being absorbed slowly, and in no great quantity, may be examined and prepared over that liquid. We shall divide this chapter into three sections. In the first, we shall take a view of the apparatus which is used by chemists for making experiments on gases: in the second, we shall point out the characters by which the different gases may be distinguished from each other; and, in the third, we shall point out the method of analysing gaseous mixtures, containing three or more gases mixed together in unknown proportions.

Sect. I.—*Of the Apparatus.*

Before attempting to make experiments on gases, it is necessary to provide both a water-trough and a mercurial-trough; the first for receiving those gases that may be examined over water; the second for those that must be examined over mercury. The water-trough may be of any dimensions at pleasure, but it is greatly for the convenience of the experimenter to have at least two; one of a large size, to serve when it is requisite to measure very large volumes of gas, and the other much smaller, in which experiments of research may be conducted. The first may be of wood lined with lead. It may be four feet long, two feet broad, and a foot and a half deep. It should have a shelf about ten inches broad and four feet long, fixed along one of the sides of the trough, about three inches below the surface. This shelf ought to be perforated with three or four holes, varying in diameter from about an inch to a quarter of an inch, and widened out below into a kind of funnel-shape. Over these holes the glass jars destined to receive the gas are to be placed, previously filled with water, and the beak of the retort or glass tube from which the gas issues is made to terminate at the funnel-shaped bottom of the hole. The small trough is best constructed of tinned copper. It may be two feet long, fifteen inches broad, and ten inches deep; and the shelf is best placed at one of its ends. Let it be provided with a single hole near the middle, but towards the edge of the shelf; and it ought to be funnel-shaped below, by soldering a bit of tinned copper round its bottom. This trough may be japanned, which improves its appearance; but the japan soon wears off the inside, if it be much used in experimental investigations. Such troughs are usually constructed of tin-plate; but they wear out so fast, that a chemist will find it cheaper in the end if he get them constructed at first of tinned copper.

One of the most convenient mercurial troughs is the kind made by Mr Newman, of Lisle Street, Leicester Square, London, of which we give a figure, (Plate LXIX. fig. 1.) from the *Royal Institution Journal*, Vol. I. p. 185. This trough would be much improved by having a round cavity near the end farthest from the glass jar, about eight inches deep and two inches in diameter, or, at least, large enough to admit the common Volta's eudiometer used in this country. The advantage of this hollow would be that the bulk of the gases let into the eudiometer, and the change of bulk produced by the explosion, would be much more conveniently estimated than at present; because the eudiometer tube could be sunk till the mercury within the tube be on a level with the surface of the mercury in the trough. At present, an arithmetical calculation is required to determine the bulk of the gas after the explosion; which, when five or six such experiments are to be made in succession, as is usually the case, makes the labour more tedious and disagreeable than it would otherwise be.

The glass jars destined for holding the gases are usually cylindrical; the larger terminate above in a knob, the smaller are sometimes flat at the top, and sometimes they are hemispherical. They are called *test glasses*. Fig. 2. represents the shape of the larger glass jars; fig. 3. exhibits a test glass: these last are usually sold in sets, fitted one within the other. The largest of these hold about thirty-five cubic inches, the smallest about two cubic inches. The size of the large glass jars varies from 200 or even 300 cubic inches, down to about 50 cubic inches. All these jars ought to be graduated, in order to indicate the bulk of gas which they contain when at use. The bulks always employed in this country are cubic inches, and tenths, or hundredths of a cubic inch.

Decomposition, Chemical.

It is necessary also to be provided with stout glass tubes, as fig. 4, of such a size as to be capable of holding a cubic inch of mercury. These tubes are shut at one end, and rounded off at the other, so that the finger may be applied to shut them up when requisite. They are graduated into 100 equal parts, so that each division is equivalent to the 100th part of a cubic inch.

The method of graduating these tubes being of considerable importance to the practical chemist, deserves to be described before we proceed farther. Provide a tube, as in fig. 5, of a very small bore, and open at both ends, and drawn out at one end into a capillary point. Next take a quantity of clean mercury, and ascertain its specific gravity with all the requisite care. Suppose you find it to be 13.422. Then as at the temperature of 60^0, a cubic inch of water weighs 252.72 grains, and $\frac{1}{100}$th of a cubic inch 2.5272 grains; it follows that at the temperature of 60^0 the 100th part of a cubic inch of mercury will weigh 33.92 grains. Weigh out 33.92 grains of the mercury, at the temperature of 60^0. Put this globule into a watch glass, and plunging the capillary point of the glass tube into the globule, apply your mouth to the other end, and suck the whole of the mercury into the tube. Then apply your finger so as to shut the orifice, and shake the tube till the mercury exactly fills the whole portion of the tube next the capillary extremity. Observe the height of the mercury in the tube, and mark the place with a file, as is done at *a* in fig. 5. This tube, supposing it made with sufficient care, will enable us to graduate our measures with considerable expedition. For we have only to plunge its capillary extremity into a quantity of clean mercury in an open vessel, and to suck up the mercury till it reaches the mark *a* ; this quantity (supposing we graduate at the temperature of 60^0) is exactly equal in bulk to the 100th part of a cubic inch. Suppose we have a tube to graduate: The first step of the process is to put a narrow ribbon of gummed paper along the whole length of the tube, taking care that the paper be applied as straight as possible. Tie this paper firmly on with a string, which is to be removed when the paper is quite dry. The next step is to place the tube in a perpendicular direction, with its shut end undermost. Take up $\frac{1}{100}$th of a cubic inch of mercury, by means of your capillary tube, pour this quantity into the tube to be graduated, apply a small ivory square or rule, so as that its edge shall be a tangent to the convex surface of the mercury in the tube, and draw a fine line, by means of a black lead pencil, across the ribbon of gummed paper. Proceed in this way till you have filled the tube with mercury, and, of course, divided it into the requisite proportional bulks, by means of the lines drawn upon the ribbon of gummed paper. Next take a fine three-cornered file, and wetting the edge of it, draw it carefully along each black line, backwards and forwards, till you have cut through the paper, and made a sufficiently distinct mark upon the tube below it. When the degrees are thus cut, write with a diamond the numbers 10, 20, 30, 40, &c. corresponding to the proper degrees, from the one end of the tube to the other; beginning the divisions, of course, at the shut end of the tube.

The test glasses are graduated exactly in the same manner; but as they are only divided into cubic inches or tenths, a tube holding the requisite quantity of mercury is employed instead of the capillary tube above described. The same method answers for graduating the large glass jars used for holding gases on the water trough; with this difference, that the ten cubic inch measure, employed for the graduation, is filled with water instead of mercury: or they may be placed upon the shelf of the trough, and ten cubic inches of air thrown up. A line is to be made with a black lead pencil, coinciding with the surface of the water in the jar; and this is to be repeated for every ten additional inches, till the whole jar is filled with air. The requisite marks are cut upon the jar by means of a triangular file, and the corresponding numbers, written with a diamond on the glass, precisely as before described.

For many experiments, on certain gases, it is convenient to have test glasses made of thin glass, and bent as in fig. 6. Pieces of phosphorus, sulphur, &c. may be put in the upper part of such tubes, in small platinum trays, and heated by means of a lamp, while surrounded by particular gases, and the changes which take place may be seen through the tube.

The next piece of apparatus which we shall describe is so simple, that it may at first sight appear needless to mention it. But we are of a different opinion, considering it as peculiarly valuable, as it saves a great deal of trouble, and greatly facilitates accurate experimenting with gases over mercury. It is often necessary to transfer determinate quantities of gas from the water trough to the mercurial trough. This must be done without introducing any water along with the gas, except what may exist in the gas in the state of vapour. This is done with the greatest facility by means of the tube represented in fig. 7, which was first used, we believe, for the purpose in question, by Mr Cavendish. This is a glass tube open at both ends; but one of the extremities is bent round, and is drawn out into a fine capillary bore. The tube is graduated into 100th parts of a cubic inch, and the degrees should be made as conspicuous as possible. A good method is to fill the lines, after they have been cut in the glass, with black or red sealing wax. When we want to transfer a given bulk of gas from the water trough to the mercurial trough, we fill this tube with mercury, and shutting the end *b* with the finger, we introduce the end *a* into a glass jar standing over water, and filled with the gas to be transferred. On removing the finger from the extremity *b*, the mercury falls down by its weight, into a vessel placed at the bottom of the trough to receive it, and the gas enters by the capillary extremity *a* to supply its place. When the gas admitted into the tube amounts to the quantity desired (half a cubic inch for example), we shut the end *b* with the finger again. We then withdraw the tube from the water trough, and wipe it dry. The end *b* is now to be placed uppermost, and the end *a* introduced under the bottom of the glass jar (filled with mercury, and standing over the mercurial

trough) destined to receive the gas. On removing the finger, the weight of the mercury in the tube forces out the gas. When it has all made its way into the destined test glass, we remove the tube, and we may, in the same way, introduce an additional quantity of any other gas, till we have made up the intended mixture.

Small glass funnels are employed, with points almost capillary for filling the narrow glass tubes with gas. These funnels, when to be used in the water trough, may be of pewter; but, for the mercurial trough, they must be of glass.

The apparatus for taking the specific gravity of gases is very important; because the specific gravity enters as an essential element in every analysis of gases. It consists of a glass flask, Plate LXIX, fig. 8, thin but stout, and furnished with a stop-cock. The larger and lighter it is so much the better. If its contents be equivalent to fifty cubic inches, it will, in general, be sufficient. The best method is to be supplied with three or four flasks similarly mounted, but differing in capacity from ten cubic inches to fifty. The small ones are used when we are provided with only a small quantity of the gas to be examined, while the larger is preferred when our supply is sufficiently large. We must be furnished with a glass jar similar to fig. 2, only supplied with a stop-cock at the upper extremity. The capacity of this jar must somewhat exceed that of the flask, fig. 8, and the two stop cocks must be such that they shall screw air-tight into each other.

The process of taking the specific gravity consists of three successive steps. The first step is to weigh the flask, fig. 8, with all the requisite accuracy. We then fix it on the plate of a good air-pump, and exhaust it, and weigh it again. Its weight will be diminished by the quantity of air which has been pumped out of it. In the third place, screw the exhausted flask to the top of the jar containing the gas whose specific gravity is to be ascertained. Great care must be taken that no drops of water have got into either of the stop-cocks. To make matters more certain, the hollow part of the female-screw may be filled with loose cotton wool. When the flask is screwed tight upon the top of the jar, one of the stop-cocks (the lower) is to be opened. You then turn the other stop-cock very slowly round, till you hear the gas beginning to make its way into the flask. Then you stop short. For the smaller the opening is the more slowly does the gas make its way, and the less chance is there of a globule of water being forced in, which would spoil the experiment. When the flask is filled with the gas, lower the jar in the water trough, till the surface of the water, within and without the jar, be on the same level. Then close the stop-cocks,—unscrew the flask, and weigh it again,—noting the change of weight that has taken place. Suppose the weight necessary to be put into the scale to which the exhausted flask is suspended, in order to restore the equilibrium, to be a, and that when the flask is filled with the gas, the weight requisite to be put into the other scale, in order to restore the equilibrium, is b. It is obvious, that a represents the weight of the air drawn out of the flask by the air-pump, and b the weight of a quantity of the gas exactly equal in bulk to the air originally drawn out. Therefore $a : b :: $ sp. gravity of air; specific gravity of the gas $= x$. But the specific gravity of air is represented by unity; of course we have this proportion, $a : b :: 1 : x$, which gives us $x = \frac{b}{a}$. So that to find the specific gravity of the gas we have only to divide b by a. Suppose the weight $a = 15.25$ grains, and $b = 12$ grains. On such a supposition the specific gravity of the gas would be 0.772.

No correction is necessary, either for temperature or for the height of the barometer, when the experiment is made in the way just described, because all gases undergo the same change in bulk when subjected to the same alteration in temperature or pressure. When the specific gravity of a gas, standing over water, is taken, the gas is always as moist as it can be at the temperature at which the experiment takes place. Thus, if the temperature be 60^0, then the vapour in the gas is sufficient to support a column of mercury of the height 0.524 inch. Let us suppose the barometer to stand at 30 inches. On that supposition, $\frac{1}{57}$th of the bulk of the gas examined is vapour. The specific gravity of steam, at the temperature of 212^0, is 0.625. It is probable that the specific gravity of vapour diminishes with the temperature at which it is produced; but we have not sufficient data to determine at what rate this diminution takes place. If we had, it would be easy to make allowance for the vapour of water present, and to deduce the true specific gravity of the dry gas. But, in the present state of our knowledge, the best way of diminishing the error is, to make the experiment at as low a temperature as possible. Thus, if we take the specific gravity of a gas standing over water, at the temperature of 32^0, the elasticity of the vapour which it contains is sufficient only to support a column of mercury 0.2 inch in height; so that the bulk of the vapour present is only about $\frac{1}{300}$th of that of the gas under examination. When the gas whose specific gravity is to be taken can only be examined over mercury, the glass jar making a part of the mercurial trough, fig. 1, is to be filled with the gas in question, the flask being such that it can be screwed to this jar as well as to those belonging to the water trough. In such cases, it is easy to dry the gas before taking its specific gravity, by introducing into the jar containing it a little dry muriate of lime, or by opening a communication between the jar holding the gas and a vessel filled with sulphuric acid. This possibility of drying the gases makes it desirable to take, occasionally, the specific gravity even of those that are not absorbed by water over mercury; especially if they happen to be light gases, as hydrogen, because the vapour of water, when it amounts to a sensible quantity, must produce a material difference on the result obtained.

It may be worth while to describe here the mode of taking the specific gravity of the vapours of such liquids as boil at moderate temperatures. The apparatus for this purpose, contrived by Gay-Lussac, is abundantly simple, and answers the purpose sufficiently well. This apparatus is represented in fig. 11

9. VV is a long narrow glass vessel, capable of holding about 90 cubic inches, and graduated into cubic inches and tenths. It is filled with mercury, and placed inverted in the vessel *aa*, containing some mercury, and which may be of iron. Small glass globules (as in fig. 10) are blown by the lamp, very thin, nearly globular, but terminating in a capillary tube. One of these glass globules is carefully weighed, and its weight noted down; it is then filled with the liquid, the specific gravity of whose vapour is to be ascertained, and the capillary point is hermetically sealed by the blowpipe. It is then weighed again. The increase in the weight denotes the quantity of liquid, which must be carefully written down. The glass globule is then to be let up into the vessel VV. It will ascend to the top, where it will remain. The cylindrical glass MM, taller than the vessel VV, and open at both ends, is then placed on the outside of VV, and plunged to a certain depth in the mercury of the vessel *aa*, where it is secured. This cylindrical vessel is now filled with water, and the vessel *aa* being placed horizontally on a furnace, heat is applied till the water is made to boil. The liquid in the glass globule, B, expands with the heat, bursts the glass globule, and is converted into vapour. The graduation of the vessel enables us to calculate the bulk of this vapour at the temperature of 212°. Knowing beforehand the weight and specific gravity of the liquid, it is easy to infer the specific gravity of the vapour at 212°. But perhaps it will be of advantage to some readers to give the formula requisite for such calculations, and to exhibit an example of the specific gravity of a vapour deduced from an experiment made by means of this apparatus.

Let P denote the weight of liquid employed, and N the number of divisions of the glass which the same liquid occupies, when converted into a vapour at the temperature of 212°. If we denote the bulk of one of these divisions by ν, $N\nu$ will be the bulk of the vapour, on the supposition that the glass does not expand. Of course, if we denote the cubic expansion of glass for one degree by k, $100\,k$ will denote the whole expansion of the vessel, on the supposition that we employ the centigrade thermometer, which is more convenient for calculation. The true volume of the vapour will be $N\nu(1+100k)$. This vapour supports the pressure, p, of the atmosphere, minus the height h of the column of mercury still remaining in the glass VV, or it is subjected to the pressure $p-h$. To reduce it to the volume which it would occupy, if it were subjected to a pressure equivalent to a column of 30 inches of mercury, we must multiply $N\nu(1+100k)$ by the inverse ratio of the pressures, 30 and $p-h$, which will change it into

$$\frac{N\nu(1+100k)(p-h)}{30\text{ inch.}}$$

Such is the volume of vapour produced by the weight, P, of the liquid in the circumstances pointed out. If P be expressed in grains, the volume of vapour produced by a grain of the liquid will be

$$\frac{N\nu(1+100k)(p-h)}{P\ 30\text{ inch.}}$$

When we employ this formula, we must take care to reduce the columns of mercury, p and h, to the same temperature at which the constant pressure of 30 inches is estimated. This is usually the temperature of 32°. The cubic dilatation of common glass for 1 centigrade degree is reckoned 0.0000262716 $=k$. The expansion of mercury for 1 centigrade degree is $\frac{1}{5412}$.

Such is the formula. Let us now illustrate its application by an example. We shall make choice of an experiment of Gay-Lussac, to determine the specific gravity of steam:

Weight of the little glass globule,	12.2162 grains.
Do. filled with water, -	21.4826
Weight of water, -	9.2664

This portion of water being introduced into the glass vessel, and raised to the boiling temperature, was converted into a quantity of steam, which occupied 220 divisions of the jar. Each of these divisions was equivalent to 0.30472256848 cubic inch. The column of mercury in the glass V V, or h, was in length 2.0473 inches. It was measured by means of the graduated rod T (fig. 9), which passes through the square C C. This rod is pushed down till it comes in contact with the surface of the mercury in the vessel *a a*. The moveable piece of wood, H, is then elevated till it correspond with the top of the column of mercury in the vessel V V. It now shows the length of the column upon the rod T.

The height of the barometer was 29.745 inches. The temperature was 15° centigrade.

The first step is to reduce these two columns of mercury to the temperature of 32°. This is done by subtracting from the first $\frac{100.\ 2.0473}{5412}=0.0378$, and from the second $\frac{15\times 29.745}{5412}=0.0824$. This subtraction reduces them respectively to 2.0095, and 29.663. We have, therefore,

$$\begin{aligned} P &= 9.2664\text{ gr.} \\ N &= 220 \\ \nu &= 0.3047225\text{ cubic inch.} \\ p &= 29.663\text{ inches.} \\ h &= 2.0095\text{ inches.} \\ p-h &= 27.653. \end{aligned}$$

The easiest method of finishing the calculation is by means of a table of logarithms; thus:

$$\begin{aligned} \text{Log. of P} &= 0.9669110 \\ \text{Log. } 30 &= 1.4771212 \\ \hline \text{L. P. } 30 &= 2.4440322 \end{aligned}$$

$$\begin{aligned} \text{Log. N} &= 2.3424227 \\ \text{Log. } \nu &= 1.4839046 \\ \text{Log. } p-h &= 1.4417423 \\ \hline \text{L. N}\,\nu\,(p-h) &= 3.2680696 \end{aligned}$$

$$\begin{aligned} \text{L. N}\,\nu\,(p-h) &= 3.2680696 \\ \text{L. P. 30 in.} &= 2.4440322 \\ \hline & 0.8240374 \ldots\ 6.6686\text{ cubic inches.} \\ \text{Log. 100 K.} \ldots &- 3.4194865 \\ \hline & -2.2435239 \ldots\ 0.0175 \\ & \qquad\qquad 6.6861\text{ cubic inches.} \end{aligned}$$

Thus it appears that a grain of water when convert-

ed into steam, at the temperature of 212°, and subjected to a pressure of 30 inches of mercury, occupies the bulk of 6.686 cubic inches.

But a grain of water, at its temperature of greatest condensation, is in bulk equal to 0.003953 cubic inch. Hence we see, that when water is converted into steam, its bulk increases $\frac{6.686}{0.003953}=1691.3$ times. Farther 6.686 cubic inches of steam, at the temperature of 212°, weigh one grain, of course 100 cubic inches weigh 14.95 grains. But 100 cubic inches of common air weigh 30.5 grains. Hence, if we reckon the specific gravity of air, 1, the specific gravity of steam will be 0.4901, at the temperature of 212°, compared to that of air at 60°; or 0.674, if we compare it with air at the temperature of 212°.

When gases, which do not unite chemically with each other, at the ordinary temperature of the atmosphere, are mixed together, no change whatever takes place in their bulk. A cubic inch of hydrogen gas, and a cubic inch of oxygen gas, being mixed together, constitute two cubic inches. Gases thus brought into contact mix together equally. The bulk of each in the above example is doubled, and its elasticity reduced to one half. The hydrogen, instead of one cubic inch, occupies the space of two cubic inches, and so does the oxygen, the density of each, of course, is reduced to one half. So that the specific gravity of such a mixture is exactly the mean of the specific gravity of hydrogen and oxygen gases.

The same case extends to the mixture of vapours, both with gases and with vapours. As long as they continue in the elastic state, they simply mix with gases, without producing any other change than an expansion occasioned by their quantity. If a cubic inch of air, and a cubic inch of any vapour, be mixed together, the mixture will become two cubic inches. The air will expand to twice its former bulk, and so will the vapour, while the elasticity of each will be reduced to one half. Proportional changes will be produced, when vapour is mixed with gases in smaller proportions. This change in bulk is very well illustrated by the piece of apparatus exhibited in fig. 11, which was contrived likewise by M. Gay-Lussac.

AB is a cylindrical glass tube, divided into equal parts, and furnished at its two extremities with the two iron stop-cocks RR′. A little above the lowest stop-cock, another tube of glass TT′, communicates with the tube AB. This apparatus being well dried, recently boiled mercury is poured into it by the stop-cock R′, till the tube AB is quite filled with that fluid, which will, of course, stand at the height A in the tube TT′. The stop-cock R′ being now shut, a globular glass vessel, furnished with the stop-cocks r, and containing the gas to be experimented on previously rendered as dry as possible, is to be screwed air-tight upon the stop-cock R′. The stop-cocks r, R′ being opened, no gas will enter into the tube AB, provided the gas in the globular vessel be merely subjected to a pressure equivalent to that of the atmosphere. But if we open the stop-cock R, the mercury will run out from its weight. The gas in the globular vessel will expand, and part of it will enter into the tube AB to supply the place of the mercury. When a sufficient quantity of the gas has entered the tube AB, the stop-cock R must be shut. The gas in AB being in a state of expansion, the surface of the column of mercury H will stand higher than the surface of mercury h in the open tube TT′, and the difference in height between these two columns will indicate the state of expansion of the gas in AB. To reduce this gas to the same elasticity as that of the external air, we have only to pour mercury into the tube TT′, till the surface of the two columns H, h, are precisely upon a level.

To introduce into the tube AB the liquid, the effect of whose vapour on the gas in the tube is to be determined, the stop-cock R″ is to be screwed upon the stop-cock R′. This stop-cock has a very small metallic funnel attached to it, into which the liquid is poured. The cock R″, instead of being perforated, as is usually the case, has merely a depression O cut in it capable of holding a drop of the liquid. This being turned, so that the depression O is in contact with the liquid, a drop of it will fill it, and being now turned round, so that O comes in contact with the stop-cock R′, which must be open, the drop of liquid will immediately begin to evaporate, and will in a short time mix itself in the state of vapour with the gas in the tube AB, augmenting its bulk. In this way, as many successive drops of the liquid may be introduced into communication with the gas as are capable of evaporating. We perceive the effect to be at an end, when the mercury ceases to rise any higher in the tube TT′. Let us suppose that a few more drops of liquid have been introduced into the tube than are capable of evaporating. If we open the undermost stop-cock R, and allow the mercury to flow out till the columns H h in the two tubes are precisely upon a level, the pressure to which the gas is subjected in the tube AB, is precisely equal to that of the atmosphere at the time. But its bulk will be greater than it was before the introduction of the vapour.

Let N = volume of the dry gas.
N′ = volume of do. when mixed with the vapour.
p = the height of the barometer.
f = the elasticity of the vapour.

It is obvious, that the total elasticity of the mixture of gas and vapour is $f + \frac{p\,N}{N'}$. But this elasticity is equal to p, which we suppose to have remained unaltered during the experiment. Therefore we have $f + \frac{p\,N}{N'} = p$, and of consequence

$$f = p \cdot \frac{(N'-N)}{N'}.$$

In making this experiment, it turns out, that the value of f is always precisely the same as the elastic force of the vapour in a vacuum at the same temperature at which the experiment was made. Hence we may easily calculate beforehand the number N′ of divisions which the mixture must occupy under the pressure p, supposing the dry gas to have pre-

viously occupied the volume N. We have only to ascertain, by means of Dalton's table, the elasticity f, which the liquid employed ought to have in a vacuum at the temperature of the experiment. Then in the above equation, every thing being known but the number N′, it is easy to deduce that quantity, which will be $N' = \frac{p}{p-f}.\ N.$

Sect. II.—*Of the Characters by which the different Gases may be distinguished.*

Before it is possible to make experimental researches on gaseous bodies, it is necessary to be familiarly acquainted with the mode of preparing the different gases at present known, with the properties of each of them, and with the means of ascertaining their purity, and distinguishing them from each other. We must in this section confine ourselves to a few observations. But the practical chemist must study in detail and experimentally the history and the properties of every individual gas.

Gases, considered as objects of experiment, must be divided into two classes: 1. Those which may be prepared and examined over water: 2. Those which can only be procured in the gaseous state, by collecting them over mercury. We shall take a view of the characters of the gases belonging to each of these classes separately.

I. *Gases permanent over water.*

The following is a list of the gases that may be collected and examined over water.

I. Supporters of Combustion.

1. Oxygen.
2. Protoxide of azote.
3. Deutoxide of azote, or *nitrous gas.*
4. Chlorine.

II. Combustible.

1. Hydrogen.
2. Carbureted hydrogen.
3. Olefiant gas.
4. Protophosphureted hydrogen.
5. Perphosphureted hydrogen.
6. Sulphureted hydrogen.
7. Tellureted hydrogen.
8. Arseniureted hydrogen.
9. Carbonic oxide.
10. Hydrocarbonic oxide.

III. Incombustible.

1. Azote.
2. Carbonic acid.

We shall state the characters by which each of these gases is distinguished, after giving a table of their specific gravity, that of air being reckoned one, and the weight of 100 cubic inches of each at the temperature of 60°, and when the barometer stands at 30 inches.

GASES.	Sp. gravity.	Weight of 100 cubit inches.
Air - - -	1.000	30.5 grains.
Oxygen - - -	1.111	33.888
Protoxide of azote -	1.528	46.598
Deutoxide of azote -	1.042	31.769
Chlorine - -	2.500	76.25
Hydrogen - -	0.0694	2.117
Carbureted hydrogen -	0.555	16.99
Olefiant - -	0.974	29.72
Protophosphureted hydrogen	0.972	29.634
Perphosphureted hydrogen	0.902	27.517
Sulphureted hydrogen	1.180	35.89
Tellureted hydrogen	——	——
Arseniureted hydrogen	——	——
Carbonic oxide -	0.972	29.652
Hydrocarbonic oxide	0.995	30.347
Azote - -	0.972	29.652
Carbonic acid - -	1.527	46.373

These three sets of gases may be readily distinguished from each other. If a taper be plunged into a phial filled with any of the supporters, it will burn either more brilliantly than in the open air, as when it is plunged into oxygen gas or protoxide of azote; or its flame will be diminished, and it will give out a great deal of smoke, as when it is plunged into chlorine. When a taper is plunged into deutoxide of azote, it is extinguished. But this gas is at once distinguished by the red colour which it assumes when mixed with common air. When a taper is plunged into a combustible or incombustible gas, it is extinguished. But if the mouth of a phial filled with a combustible gas be held to a lighted candle, the gas will catch fire and burn. Whereas, no such combustion can be perceived when a phial, filled with an incombustible gas, is held to a lighted candle. Thus we can easily determine, whether a gas collected over water be a supporter of combustion, combustible, or incombustible.

1. Oxygen is one of the most important of these gases; because it is employed as a means of ascertaining the nature and constitution of all the combustible gases. Its properties, therefore, ought to be carefully and accurately studied, in the first place, by every person who wishes to become an adept in the analysis of gaseous bodies.

Oxygen gas is colourless,—has no taste nor smell, and is not sensibly absorbed by water. If it be mixed with twice its volume of nitrous gas over water, the mixture becomes red, and is almost wholly absorbed by the water. A solution of protosulphate of iron, recently saturated with deutoxide of azote, if it be put in contact with oxygen gas, in a graduated tube, and the liquid be agitated with it for about five minutes, absorbs the oxygen gas completely. Oxygen gas is absorbed, also, by a solution of hydrogureted sulphuret of lime. It is requisite to have placed this liquid in contact with a certain portion of common air, before it be employed as a test of oxygen; because it has the property of absorbing a certain portion of azote as well as oxygen.

On that account we must saturate it with azote beforehand. Unless this precaution be taken, the oxygen under examination might be mixed with a portion of azote without our perceiving it. The simplest and most convenient apparatus for experiments on the purity of oxygen gas by absorption by means of a liquid, is that represented in fig. 12. A is a glass tube capable of holding a cubic inch, and graduated into 100 equal parts. B is a glass cylinder into which the extremity of the tube A fits, being carefully ground to each other with emery. To the glass cylinder B, the caoutchouc bottle C is fixed. The glass cylinder is of such a size as to fit tightly to the mouth of the bottle, and the mouth is tied firmly round the cylinder by a waxed silk thread. The caoutchouc bottle ought to be of such a size as to be capable of containing more than the contents of the whole glass tube A. To examine the purity of oxygen gas by means of this apparatus, we proceed as follows: Fill the tube with the oxygen gas. Fill the caoutchouc bottle with the liquid; for example, a solution of protosulphate of iron, saturated with deutoxide of azote. Plunge the bottle under the surface of the water in the trough, and introduce into its mouth the end of the tube A, which is ground to fit the glass collar B. Remove the apparatus from the trough, and, holding the apex of the tube A downwards, gently squeeze the caoutchouc bottle. The liquid will displace the gas, and gradually fill the tube. The apex of A is now to be turned upwards, and the liquid allowed to run back into the bottle. In this manner the liquid is to be kept running continually backwards and forwards in the tube, till the gas has diminished as much as it is capable of diminishing. The quantity absorbed is shown by the portion of the tube filled with liquid, when the apex of A is held vertical; for the pressure of the atmosphere on the caoutchouc bottle is sufficient to prevent the gas in the tube from remaining in a state of expansion. If the oxygen be pure, it will be absorbed completely. The portion of gas remaining, if there be any, is almost always azote.

Oxygen gas is usually prepared from the peroxide of manganese, or the chlorate of potash. Almost pure oxygen gas may be obtained from manganese, if it be collected after the gas has been coming over for some time, and before the current begins to slacken. The easiest way of determining the purity of oxygen gas is the following: Mix one volume of the oxygen to be examined with two volumes of pure hydrogen gas, and cause an electric spark to pass through the mixture. Note the diminution of bulk. One-third of this diminution is oxygen gas. Let the original volume of the oxygen be a; let the third part of the diminution of bulk produced by the combustion be a'; then the bulk of pure oxygen in the portion of the gas examined is $a - a'$. Suppose the volume of the oxygen gas examined to be 100, the hydrogen added to be 200, and the diminution of bulk to be 294. The third part of 294 is 98. Here the quantity of pure oxygen in 100 volumes of the gas is 98; of course the oxygen is a mixture of 98 volumes of pure oxygen, and 2 volumes of azote.

The piece of apparatus used for these explosions of oxygen, mixed with any combustible gas, is usually known by the name of Volta's eudiometer. It consists of a very thick glass tube (fig. 13.) about eight inches long, and about one-fifth inch of internal diameter, capable of containing about two cubic inches, and graduated into tenths of a cubic inch. Towards the top, two small holes are drilled in it, opposite to each other. Into these, two brass wires are cemented; they penetrate into the inside of the tube, and their blunt ends approach within a small distance of each other. The end of each, on the outside of the tube, terminates in a small ring. A spark from an electrical machine or a Leyden phial, is made to pass from one of these wires to the other within the tube. This spark sets fire to the gaseous mixture, and causes its explosion. The tube, before the explosion, is screwed firmly into an iron claw attached to an iron pillar. This pillar is screwed to the mercurial trough, when the experiments are to be made over mercury; but it is more convenient for experiments over water, to have it screwed to a small moveable box, and to have a little tin plate tube, which is to be filled with water, and the eudiometer put into it before it is fixed to the iron pillar. Fig. 14. represents this iron pillar. A is the short cylinder lined with leather, which opens upon a hinge, and allows the introduction of the glass tube; A is then closed and screwed firmly down. The elasticity of this iron pillar and claw moderates the shock of the explosion, and prevents the eudiometer from being broken. The French chemists have a stop-cock at the bottom of their eudiometers, to shut it during the explosion. The object of this precaution is to prevent the possibility of any of the gas from being driven out of the tube by the expansion which always takes place at the instant of the explosion. But this is sufficiently guarded against by making the experiment upon a small scale. For example, $\frac{20}{100}$ of a cubic inch of oxygen, and $\frac{40}{100}$ of a cubic inch of hydrogen gas. The tube should be plunged into a vessel filled with water, and at least six inches deep. When there is a stop-cock at the bottom of the tube, the water of the vessel cannot make its way in to supply the place of the gas condensed by the explosion. The consequence is the formation of a vacuum in the tube. This occasions the evolution of the air, which the water in the tube always contains. This air mixing with the residual gas increases its quantity, and leads the experimenter into an error with respect to the purity of his gas.

2. Protoxide of azote is easily distinguished from oxygen by the following properties: If it be left standing over water, it is gradually absorbed and disappears. For water has the property of absorbing about three-fourths of its bulk of this gas. Hence if a phial be filled with water, and a quantity of this gas be let up into it, if we agitate the phial, a portion of the gas will be absorbed, and the water impregnated with it has acquired a sweet taste. We perceive the same sweet taste if we draw a little of the gas into our mouth through a tube. When a lighted taper is plunged into protoxide of azote it burns with great splendour; but the combustion continues only for an instant or two, much shorter than when the same experiment is made with oxygen gas.

The only gaseous body with which protoxide of azote is liable to be contaminated is common air, and azotic gas. It ought to be examined, in the first place, for oxygen gas. This is best done by putting a given volume of it into a jar standing over mercury, and putting up into it a stick of phosphorus with a few drops of water. Allow it to remain in this state for twenty-four hours, in a temperature which should not be lower than 60°. Observe the diminution of the bulk which has taken place. That diminution indicates the quantity of oxygen which the gas contained. If no diminution whatever has taken place, we may conclude that our protoxide of azote contains no oxygen, and, of course, no common air mixed with it.

To determine whether protoxide of azote be contaminated with azotic gas, the best mode of proceeding seems to be the following: Mix a measured portion of the protoxide of azote with its own bulk of pure hydrogen gas, and explode the mixture in a Volta's eudiometer. Note the diminution of bulk. This diminution indicates the quantity, by measure, of protoxide of azote present in the mixture before the explosion. Suppose we mix together 20 measures of protoxide of azote and 20 measures of pure hydrogen gas, and that, after the explosion, we find the residue to be 20 measures, 20 measures of course have diappeared, which indicates 20 measures of pure protoxide of azote. The protoxide in this case was absolutely pure. Suppose a mixture of

20 measures protoxide of azote,
20 measures hydrogen,

and the residue to be 24 measures, 16 measures have disappeared. In this case our protoxide of azote is a mixture of

16 measures pure protoxide of azote,
4 measures azote;

or it contains the fifth part of its bulk of azotic gas.

This mode of examining the purity of protoxide of azote is founded on the following facts, which have been ascertained by experiment. Protoxide of azote is composed of

$$\left.\begin{array}{l}\text{1 volume oxygen gas}\\ \text{2 volumes azotic gas}\end{array}\right\}\text{ condensed into 2 volumes.}$$

Hydrogen gas requires half its bulk of oxygen gas in order to be completely changed into water by combustion. Hence, when two volumes of hydrogen are mixed with two volumes of protoxide of azote, the whole hydrogen and oxygen disappears, and there remain two volumes of azotic gas, which is precisely equal to the original bulk of the protoxide of azote.

3. Deutoxide of azote, or nitrous gas, is the most easily recognized of all the gases, and its purity ascertained with great facility. It is colourless and tasteless, and not sensibly absorbed by water. When mixed with common air or oxygen gas, its bulk diminishes, and it assumes a red colour, and the smell of nitric acid. If the mixture be made over water, the red colour disappears very speedily, because the nitric acid formed is absorbed by that liquid. A saturated solution of protosulphate of iron in water absorbs this gas, and acquires a dark brown or almost black colour. To determine the purity of this gas, fill with it a graduated glass tube, of so narrow a bore that it may be shut up by the point of the finger. Cover its open end with the finger, and introduce it into a small cup, containing a solution of protosulphate of iron. When the liquid has entered perceptibly into the tube, cover its end with the finger, and invert it, that the liquid may run down to the farther extremity of the tube; then introduce it again into the protosulphate, and withdraw the finger. An additional quantity of protosulphate of iron will rush into the tube, to supply the place of the protoxide of azote absorbed. Repeat this process till the bulk of the gas ceases to diminish. The residue indicates the volume of azotic gas with which the nitrous gas is mixed.

4. Chlorine gas has a yellow colour, and a very strong suffocating odour, similar to that of aqua regia. Water absorbs about twice its bulk of it. Hence it may seem, at first sight, an improper gas for being examined over water. But mercury absorbs it very rapidly, and in still greater abundance, forming with it a concrete substance, which lines the inside of the glass jars, and prevents us from seeing what is going on within: so that, upon the whole, it is better to collect this gas over water than over mercury. The best way, when it is prepared for use, is to fill glass phials with it, having ground stoppers, very well fitted, by means of emery.

To determine the purity of chlorine gas, mix it over water with its own bulk of pure hydrogen gas, and explode the mixture in a Volta's eudiometer. Note the diminution of bulk; half of that quantity indicates the bulk of pure chlorine gas in the mixture. The reason of this is, that chlorine combines with its own volume of hydrogen, and is converted into muriatic acid gas, which is absorbed by the water, and disappears.

5. Hydrogen gas, like oxygen, must be familiarly known to the practical chemist, because it is employed to ascertain the purity of the gaseous supporters. We must, therefore, know the methods of obtaining it in a state of sufficient purity, and of determining the foreign gaseous bodies with which it is liable to be contaminated. To prepare hydrogen gas in a state of absolute purity, is a task so difficult, that it seems to have been seldom accomplished. Hence the great difficulty of determining its specific gravity, and the reason why this gravity, as determined by experiment, is somewhat above the truth. But, to procure it pure enough for all the purposes of the examination of gases is sufficiently easy. The most convenient apparatus for the purpose is represented by fig. 15. A is a glass flask, capable of holding about 30 cubic inches; and B is a bent glass tube, fitted by grinding to the mouth of the flask A. Put into the flask a quantity of zinc, broken down into small pieces; then fill the flask to the brim with a mixture of one part of sulphuric acid and three parts of water. Plunge the flask and the bent tube B under the surface of the water, in the water trough; insert the tube B into the flask, taking care, beforehand, that the whole of the air which the tube contained is expelled; now place the flask A upon a stand, so that the end of the bent tube B is under

the surface of the water in the water trough, and so situated that a glass jar can be placed over it. The hydrogen gas passes through the bent tube B, and is collected in the glass jar sufficiently pure for all the purposes of experiment.

Hydrogen gas, when pure, has no smell, and, when burnt, gives out so little light, that the colour of the flame cannot be determined. But, as usually prepared, it has a peculiar smell, somewhat similar to that produced by electricity, and it burns with a bluish, greenish, or reddish flame, owing to its being contaminated with phosphorus, sulphur, zinc, or iron. Indeed, when hydrogen is made to issue through a brass tube, and kindled, the colour of the flame is owing to small particles of the brass, which are separated and mix with the flame. Hydrogen is not sensibly absorbed by water. If it be mixed with half its bulk of oxygen gas, and an electrical spark passed through it, an explosion takes place, and the whole gaseous mixture disappears, being converted into water. Therefore, to ascertain the purity of hydrogen gas, mix it with its own volume of oxygen gas, and explode it by electricity. Note the diminution of bulk. Two-thirds of that diminution indicate the bulk of the hydrogen gas contained in the mixture before combustion. Suppose we mix 20 volumes of hydrogen gas with 20 volumes of oxygen gas, and that the diminution of bulk, after the explosion, amounts to 30 volumes. Two-thirds of 30 being 20, we infer from the result, that the hydrogen gas was perfectly pure. Suppose the diminution of bulk to amount to 27 volumes, two-thirds of 27 being 18, we infer that the hydrogen gas is a mixture of

18 volumes pure hydrogen,
2 volumes of some other incombustible gas.

6. Carbureted hydrogen gas is colourless, and burns with a yellowish white flame, like that of a common candle. It is not sensibly absorbed by water, and has neither taste nor smell. It requires for complete combustion twice its volume of oxygen gas, and there remains after combustion a quantity of carbonic acid gas, exactly equal in volume to the original gas. Hence it is obvious, that carbureted hydrogen is a compound of one volume of carbon and two volumes of hydrogen gas, condensed into one volume. One half of the oxygen combines with the carbon, and forms carbonic acid gas; while the other half of the oxygen combines with the two volumes of hydrogen, and is converted into water.

7. Olefiant gas is colourless, and destitute of taste or smell. It burns with a white coloured flame, and gives out much more light than any other gas. Water absorbs about $\frac{1}{7}$th of its weight of this gas; a proportion so small, that it is not perceptible in common experiments. For complete combustion it requires three times its volume of oxygen gas. The residue is carbonic acid gas, constituting twice the volume of the original gas. Hence it is obvious, that olefiant gas is composed of two volumes of carbon and two volumes of hydrogen gas, condensed into one volume. Two volumes of the oxygen combine with the carbon, and constitute two volumes of carbonic acid gas; while the remaining volume of oxygen gas unites with the two volumes of hydrogen, and is converted into water.

When olefiant gas is mixed with its own volume of chlorine, the two gases combine and condense into a liquid, which, if the experiment be made over water, has a white colour, and a considerable opacity. This property is of considerable importance, as it enables us to detect the presence of olefiant gas, when mixed with carbureted hydrogen, carbonic oxide, or any other similar combustible gases. We have only to mix a determinate volume of the gas with chlorine, to allow the mixture to remain for a few minutes over water. If any globules of chloride of olefiant gas appear, we are certain of the presence of olefiant gas in the mixture. By washing out the unabsorbed chlorine, and noting the diminution of bulk, we can determine the proportion of olefiant gas which our mixed gas contains.

8. The two species of phosphureted hydrogen gas may be noticed together. Protophosphureted hydrogen gas may be obtained, by heating crystallized phosphorous acid, which is a hydrate. Perphosphureted hydrogen is procured pure, by putting phosphuret of lime into a small flask, completely filled with water, and receiving the gas which is extricated in glass jars, filled with water, and standing inverted on the shelf of a water trough. Protophosphureted hydrogen is a compound of one volume of phosphorus and two volumes of hydrogen condensed into one volume, while perphosphureted hydrogen is a compound of one volume of phosphorus and one volume of hydrogen, condensed into one volume; or the first may be considered as a compound of one atom phosphorus, and two atoms hydrogen, while the second is a compound of one atom phosphorus and one atom hydrogen. Water absorbs about the eighth part of its volume of each of these gases. They have the smell of garlic. Perphosphureted hydrogen burns spontaneously when it comes in contact with common air or oxygen gas; but perphosphureted hydrogen does not take fire unless it be heated at least to the temperature of 212^{0}, or unless an electric spark is made to pass through it. Perphosphureted hydrogen is absorbed completely by a solution of chloride of lime *(oxymuriate of lime)*. This property, discovered by Mr Dalton, enables us to ascertain the purity of this gas, and to separate it from any other gases with which it may be mixed. When one volume of perphosphureted hydrogen is mixed with one volume, or one and a half volume, or two volumes of oxygen gas over water, combustion takes place in all of these cases, and the two gases completely disappear; the phosphorus being converted into hypophosphorous acid, phosphorous acid, or phosphoric acid respectively, according to the volume of oxygen gas employed.

9. Sulphureted hydrogen gas is colourless. It has a strong disagreeable smell, similar to that of rotten eggs. Water absorbs about two and a half times its volume of this gas when pure; but if the gas be mixed with hydrogen gas, which is very frequently the case, water is scarcely capable of absorbing more than its own bulk of it. This gas burns with a blue flame, and sulphur is deposited during the combustion. If a drop of acetate of lead

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be let fall into water impregnated with it, a dark brown or blackish precipitate immediately appears. Arsenic is thrown down by it, yellow, and antimony, orange. For complete combustion, it requires one and a half times its volume of oxygen gas; and if the experiment be made over water, the whole gaseous matter disappears, being converted into water and sulphurous acid. Hence it is easy to determine the purity of sulphureted hydrogen gas.

10. Tellureted hydrogen and arseniureted hydrogen gases are still so imperfectly known, that we cannot attempt to give their characters here. But they are not likely to occur in any analytical investigations of gases.

11. Carbonic oxide gas is colourless, and destitute of taste and smell. It is not sensibly absorbed by water; nor are we acquainted with any substance capable of absorbing it in considerable quantities. It burns with a blue flame, gives out but little light, and is very easily extinguished. For complete combustion, it requires half its volume of oxygen gas. The residue, after combustion, is carbonic acid, and is equal to the bulk of the carbonic oxide before the combustion. If equal volumes of carbonic oxide and chlorine gases, both previously well dried, be mixed together over mercury, and exposed for a short time to the light of the sun, the bulk of the mixture is reduced to one half. If a little water be let up to this new gas, the bulk is not altered; but the gas remaining, which is equal in volume to the original quantity of carbonic oxide employed, is carbonic acid gas, which is absorbed completely, if a sufficient quantity of caustic potash be let up to it.

12. Hydro-carbonic oxide is a gas lately discovered by Dr Thomson, and is by no means unlikely to occur in the complex inflammable gases obtained by distilling vegetable or animal substances. It is easily procured pure by exposing a mixture of prussiate of potash and concentrated sulphuric acid to the heat of a lamp in a small retort. This gas is colourless, has a peculiar smell and an aromatic taste, and is not sensibly absorbed by water. It burns with a deep blue flame, and is much more combustible than carbonic oxide. For complete combustion, three volumes of the gas require to be mixed with two volumes of oxygen gas, and an electric spark passed through the mixture. The residue, which amounts to three volumes, is carbonic acid gas. Hence it is obvious that hydro-carbonic oxide is a compound of three volumes carbonic oxide, and one volume hydrogen condensed into three volumes; one and a half volume of the oxygen unites with the carbonic oxide, and converts it into carbonic acid, without altering its bulk, while the remaining half volume of oxygen unites to the volume of hydrogen, and becomes water.

13. Azotic gas is colourless and destitute of taste and smell, and not sensibly absorbed by water. It extinguishes a burning taper, and is itself incombustible. We are not acquainted with any substance capable of absorbing it, or of combining with it rapidly; so that the properties by which it is distinguished are all negative. If we have a sufficient quantity of this gas to determine its specific gravity, and if we find the negative properties above mentioned to belong to it, we cannot be much deceived in our conclusion respecting the nature of this gas. When very great accuracy is necessary, we may make the following experiment: Mix a small quantity of the gas, supposed to be azote, with twice its volume of oxygen. Let up a little of this mixture into a small glass syphon filled with mercury, and placed so that one leg of the syphon stands in one wine glass containing mercury, and the other in another. Let up to the gas a few drops of water, tinged blue with litmus. Then cause electrical sparks to pass through the gas at the top of the syphon, from one of the columns of mercury to the other. If the gas be azote, the blue liquid will become gradually red, in consequence of the formation of nitrous acid.

14. Carbonic acid gas is colourless. It affects the nose with a peculiar pungent sensation, and has an acidulous and agreeable taste. Water absorbs rather more than its own bulk of it, and hence, if it be allowed to stand upon the water-trough, it soon disappears. It renders lime water, barytes water, and strontian water, milky, and is completely absorbed by a sufficient quantity of these liquids. Hence its nature is easily recognized, and it may be separated from those gases with which it is mixed, and its bulk ascertained. When gases standing over mercury contain a mixture of carbonic acid gas, the best substance to separate it from the other gases with which it is mixed, is a solution of caustic potash in water.

Carbonic acid gas is not only incombustible, but it very much weakens the combustibility of those inflammable gases with which it may be mixed. When carbonic oxide is mixed with a fifth or a sixth of its bulk of carbonic acid gas, it is very difficult to make it burn. When common air is mixed with $\frac{1}{10}$th of its bulk of carbonic acid gas, a burning taper, when plunged into it, is immediately extinguished.

II. *Gaseous Bodies which must be examined over Mercury.*

The following table exhibits a list of these gases.

I. Combustible.

1. Ammonia.
2. Cyanogen.

II. Acid and incombustible.

1. Muriatic acid.
2. Sulphurous acid.
3. Fluoboric acid.
4. Fluosilicic acid.
5. Hydriodic acid.

Before stating the characters of these gases, we shall give a table of their specific gravities, and of the weight of 100 cubic inches of each when the barometer stands at 30 inches, and the thermometer at 60^0. The specific gravity of common air is reckoned 1.

Decomposition, Chemical.

GASES.	Sp. Gravity.	Weight of 100 cubic inches.
Ammonia - -	0.590	18.000
Cyanogen - -	1.804	55.028
Muriatic acid - -	1.284	39.162
Sulphurous acid - -	2.222	67.771
Fluoboric acid - -	2.371	72.312
Fluosilicic acid - -	3.573	108.092
Hydriodic acid - -	4.375	133.434

These two sets of gases may be easily distinguished from each other, by the combustibility of the first set, and the incombustibility of the second.

1. Ammoniacal gas is colourless. Its smell is exceedingly strong and well known, as the odour which distinguishes hartshorn, or the volatile alkali of apothecaries. Its taste is caustic, like that of potash; and, when drawn into the mouth, it very speedily destroys the skin. When placed in contact with water tinged blue with red cabbage, radishes, or violets, it immediately changes the blue colour into green. Water absorbs 780 times its volume of this gas. It is absorbed, likewise, by caoutchouc, and by many other bodies. It is absorbed in considerable quantity by fused muriate of lime, and may be afterwards expelled unaltered from that substance, by the application of a moderate heat.

When ammoniacal gas is put into a dry glass tube, and electrical sparks are passed through it for a considerable time, its bulk is just doubled, and it is converted into a mixture of three volumes hydrogen and one volume azotic gas. Hence it is obvious that ammonia is composed of

$$\left.\begin{array}{l}\text{3 volumes hydrogen}\\ \text{1 volume azote}\end{array}\right\}\text{condensed into 2 volumes.}$$

If we mix two volumes of ammonia with $1\frac{1}{2}$ volume of oxygen, and pass an electrical spark through the mixture, an explosion takes place, water is formed, and there remains a quantity of azotic gas equal to half the original volume of the ammonia. When this gas is mixed with its own volume of sulphurous acid, muriatic acid, or carbonic acid gases, the whole gaseous matter disappears, and a white powder comes in place of it, composed of sulphate of ammonia, muriate of ammonia, or carbonate of ammonia, according to the nature of the acid gas used.

2. Cyanogen gas is colourless. It has a peculiar smell, so pungent that it occasions a flow of tears, and a considerable degree of pain, when applied to the nostrils. This gas burns with a purple flame. Water absorbs $4\frac{1}{2}$ times its volume of it, and alcohol 23 times its volume. It reddens the tincture of litmus. If we mix one volume of cyanogen with two volumes of oxygen, and pass an electric spark through the mixture, a violent detonation takes place, and the bulk of the gaseous mixture is not altered; but it is converted into a mixture consisting of two volumes of carbonic acid, and 1 volume of azotic gas. Hence we see that this gas is composed of two volumes carbon and one volume azote, condensed into one volume. The oxygen combines with the carbon, and is converted into carbonic acid, while the azote is disengaged in the gaseous state.

3. Muriatic acid gas is colourless. It has a peculiar smell, and a strong acid taste. It reddens vegetable blues, and smokes when mixed with atmospheric air, or any gas containing aqueous vapours. Water absorbs 516 times its bulk of this gas, and acquires the appearance and properties of the common muriatic acid of the shops. When mixed with its own volume of ammoniacal gas, the mixture is condensed into a white powder, which possesses the properties of sal ammoniac. If a lighted taper be plunged into a phial full of muriatic acid gas, it goes out, but the flame, before it is extinguished, assumes a green colour. Several of the hydrates of the metallic oxides absorb muriatic acid gas readily. For example, the hydrate of copper, and the hydrate of iron. Black oxide of manganese, when assisted by heat, converts it into chlorine, obviously by absorbing the hydrogen, which constitutes one of its constituents. If this experiment could be made with precision, the muriatic acid would be reduced to one half of its original bulk.

4. Sulphurous acid gas is colourless. It has an exceedingly pungent and disagreeable odour, precisely similar to that of burning sulphur. It reddens vegetable blues, and gradually destroys the colour altogether. If a quantity of peroxide of lead is placed in contact with this gas, it gradually absorbs it completely, being converted into sulphate of lead. By this method, which was first employed by Berzelius, the purity of sulphurous acid gas may be ascertained, and it may be readily separated from any other gases with which it may happen to be mixed. Water absorbs about 43 times its bulk of this gas. When three volumes of sulphureted hydrogen gas and two volumes of sulphurous acid gas are mixed together, they condense each other completely into an orange-coloured solid substance. having an acid taste. This action of these two gases on each other was first observed by Mr Kirwan. Berthollet afterwards made some additional remarks on it. But the subject was first accurately examined by the writer of this article, who has found the result as above-stated. When the solid formed is digested in water, it is gradually changed into common sulphur.

5. Fluoboric acid gas is colourless. Its smell is somewhat similar to that of muriatic acid. Its taste is exceedingly acid. Water is capable of absorbing 700 times its bulk of this gas. The specific gravity of this solution is 1.77. It possesses a certain degree of viscidity like sulphuric acid, and requires a high temperature to cause it to boil. This property enables us to distinguish it from muriatic acid. The two gases may likewise be readily recognized by their specific gravities; that of fluoboric acid being much higher than that of muriatic acid gas. It is absorbed in considerable quantities by sulphuric acid. This gas is by no means likely to occur in analytical researches on the gases.

6. Fluosilicic acid gas is colourless. Its taste is intensely acid, and its smell somewhat similar to that of muriatic acid. When it comes in contact with water it is absorbed, and at the same time a quantity of silica is deposited in a gelatinous state. This

character is peculiar to fluosilicic acid gas, and is sufficient to distinguish it from every other gas. When water has absorbed 360 times its bulk of this gas, the quantity of silica deposited is so great that the whole liquid has disappeared, being absorbed by the silica; the absorption of course cannot be carried farther.

7. Hydriodic acid gas is colourless. Its smell is similar to that of muriatic acid, and its taste is exceedingly sour. It is distinguished from all the preceding gases by its great specific gravity, and by its not being capable of standing over mercury without undergoing decomposition. The iodine combines with the mercury, and forms iodide of mercury, under the form of a red powder, while a quantity of hydrogen gas remains, equal in bulk to half the hydriodic acid gas. This gas is not likely to occur in chemical analyses of gases. But if it should, it may be easily recognized by the preceding properties.

Sect. III.—*Of the Analysis of Gases.*

An accurate knowledge of the properties of the different gases, as detailed in the preceding section, will enable the practical chemist to ascertain the constituents of any mixture of gaseous bodies, that may present itself for his examination. We shall, in this section, give a few examples of the mode followed in analysing such mixtures, and we shall chiefly select actual analyses which we have ourselves performed, as more likely to lead the student to a practical knowledge of the subject than imaginary mixtures, never likely to occur, except to the fancy of the writer.

I. *Analysis of common Air.*

Common air has been ascertained to be a mixture of 21 volumes of oxygen gas, and 79 volumes of azotic gas. To determine its composition, it is requisite merely to know the volume of oxygen gas which it contains. We may infer, without any sensible error, that the residue is azotic gas; for the volume of carbonic acid gas which common air contains is so small, that it may be neglected without any sensible error. The easiest method of analysing common air, is to mix it with half its volume or more of hydrogen gas, and fire the mixture in a Volta's eudiometer, by means of an electric spark. Note the diminution of bulk. One-third of that diminution is the volume of oxygen gas contained in the common air employed. The following experiments were made on a bottle full of air, collected in St James's Park, by carrying the bottle filled with water, and emptying out the water in the Park.

Volumes of air.	Volumes of hydrogen.	Residue after Combustion.	Diminution of bulk.	Oxygen gas in the air.
100	50	87	63	21
100	50	87	63	21
100	60	97	63	21
100	60	97	63	21

The same method of analysis will answer for any mixture of oxygen and azotic gas, in any proportion whatever.

2. *Analysis of Oxygen Gas mixed with an inflammable Gas.*

It is possible that a mixture of oxygen gas with hydrogen gas, carbureted hydrogen gas, carbonic oxide, or sulphureted hydrogen gas, may be presented for examination. Such a mixture, indeed, is not likely to occur in any gases extricated by chemical processes, however complicated, but it may be made artificially in the laboratory for some purpose or other. How are we to proceed in determining its composition?

1. The first step in the process is to ascertain the presence of oxygen gas, and the proportion of that gas in the mixture. For this purpose, put a small quantity of it (a cubic inch for instance) into a wide graduated tube filled with water, and inverted over the water trough, and let up into it its own volume of deutoxide of azote. If no red colour nor diminution of bulk is produced, we may conclude that the gas contains no oxygen gas. But if the colour becomes red, and the bulk diminishes, oxygen gas is present. To determine the proportion of oxygen present, the easiest method is to use the eudiometer represented in fig. 12. Fill the tube A with the gas, and the bottle C with a solution of protosulphate of iron, saturated with deutoxide of azote. Introduce the tube A into the glass ring B, and agitate the liquid backwards and forwards in the tube till the whole oxygen gas is absorbed. The ascent of the liquid in the tube will indicate the bulk of the oxygen gas.

2. The second step is to determine the nature of the inflammable gas, and its proportion. If we set fire to the portion which we have deprived of oxygen gas, the colour of the flame will give us some idea of the nature of the inflammable gas. If the colour of the flame be blue, the gas is carbonic oxide; if it be white, or yellowish white, the gas is olefiant gas, or carbureted hydrogen; if it be reddish or greenish, and gives out so little light as to be scarcely visible, the gas is hydrogen. But a very little practical skill will enable the experimenter to dispense with this criterion, which at best is rather ambiguous. Take a given volume of the mixed gas, and add to it as much oxygen as will make the volume of the oxygen equal to that of the inflammable gas. Put this mixture into a Volta's eudiometer, and pass an electrical spark through it. A detonation will take place. Note down the diminution of bulk. Fill a graduated tube with lime water, and let up into this tube the residual gas. If it renders the lime milky, the residual gas contains carbonic acid. Hence the inflammable gas under examination must have been carbonic oxide, carbureted hydrogen, or olefiant gas. Note the diminution of bulk produced by the lime water. This diminution, calculated from the original bulk of the residual gas after the explosion, before it was poured out of the Volta's eudiometer, indicates the volume of carbonic acid formed by the combustion. To the residual gas thus deprived of its carbonic acid, let up a measured volume of nitrous gas. If the bulk of this mixture is

not diminished, we infer, that the residual gas contains no oxygen gas. If a diminution take place, the residual gas contains oxygen: and the volume of oxygen may be determined by multiplying the diminution of bulk by $\frac{7}{19}$ or 0·3684. If no oxygen be contained in the residual gas, we must repeat the experiment, mixing a greater proportion of oxygen with the inflammable gas, and we must continue to increase the proportion of oxygen till we find a portion of it remaining in the residual gas after the explosion. This quantity, subtracted from the volume of oxygen present in the mixture before the explosion, gives us the volume of oxygen gas requisite to consume a given volume of the inflammable gas. This fact, together with the quantity of carbonic acid formed by the explosion, puts it in our power to determine the nature of the inflammable gas. If the oxygen necessary for the complete combustion of the gas be ½ the volume of the combustible gas, and if no carbonic acid gas is evolved by the explosion, then the gas is hydrogen. If the gas requires half its volume of oxygen, and if its own volune of carbonic acid gas is formed, the gas is carbonic oxide. If twice the volume of the gas of oxygen by requisite, and if the quantity of carbonic acid formed be equal to the original volume of the inflammable gas, the gas is carbureted hydrogen. If thrice the volume of oxygen be necessary, and if twice the volume of carbonic acid be formed, then the gas was olefiant gas. The following table of experimental results will give the reader a correct idea of the way of performing these experiments.

No. of Experiments.	Volumes of Inflammable Gas.	Volumes of Oxygen.	Residue after Explosion.	Do. when washed with lime water.	Nitrous Gas added.	Diminution of Bulk.
1	20	20	10	10	20	27
2	20	20	30	10	20	27

In the first of these experiments, it is obvious that the inflammable gas was pure hydrogen. For no carbonic acid was formed by the explosion. The diminution of bulk, when the residual gas was mixed with twice its volume of nitrous gas, was 27 and 27+0.3684=10 very nearly. Hence the whole residual gas was oxygen. Thus we see that the gas, for its complete combustion, required half its volume of oxygen, and that no carbonic acid gas was formed by the explosion. But these characters point out unequivocally hydrogen gas.

In the second experiment, we see that a quantity of carbonic acid was formed equal in volume to the volume of inflammable gas, and that the whole residue, after the absorption of the carbonic acid by the lime water, was oxygen. Therefore the inflammable gas required, for complete combustion, half its volume of oxygen gas, and was converted into its own volume of carbonic acid gas. It was therefore *carbonic oxide.*

No. of Experiments.	Volumes of Inflammable Gas.	Volumes of Oxygen.	Residue after explosion.	Ditto washed in Lime water.	Nitrous Gas added.	Diminution of Bulk.	Oxygen in residual Gas.
1	39.5	28.5	100	94.5	37	0	0
2	16.8	50.24	36.0	1	42	3	1
3	16.8	52.24	36	0			
4	16.8	50.8	35	0			
Average.	100	302	Carbonic 208	acid formed.			

From these experiments we may conclude that the gas examined was olefiant gas. The increase of volume observable in the first experiment, when this gas is exploded with a volume of oxygen gas less than its own, is a remarkable property which characterizes this gas. From the average of the other three experiments, we learn that the gas required almost exactly thrice its volume of oxygen gas for complete combustion, while there were formed twice its volume of carbonic acid gas. Now this is the character of olefiant gas.

No. of Experiments.	Volumes of Inflammable Gas.	Volumes of Oxygen Gas.	Residue after Combustion.	Ditto Washed in Lime Water.	Nitrous Gas added.	Diminution of Bulk.	Oxygen in Residue.
1	21.6	44.7	22	0.4			
2	21.6	53.5	30.1	7.1	40	19	7
3	21.6	44.7	22.5	0.5			
Average.	100	205	Carbonic 104	acid formed.			

From these experiments we see that the gas under examination required, for complete combustion, very nearly twice its volume of oxygen gas, and that very nearly its own volume of carbonic acid gas was formed. Now these properties characterize carbureted hydrogen gas.

3. *Analysis of a Mixture of Inflammable Gases.*

If we have a mixture of different inflammable gases to analyse, the process to be followed is very similar to that exhibited in the last case, the chief difference lies in the inferences drawn from the experiments,

1. If the gaseous mixture is destitute of smell, it can consist only of hydrogen, olefiant gas, carbureted hydrogen, and carbonic oxide, mixed together. If it has the smell of rotten eggs, it contains sulphureted hydrogen; while the smell of garlic indicates the presence of phosphureted hydrogen gas. Sulphureted hydrogen gas may be separated, and its volume determined, by filling the eudiometrical tube, fig. 12, with the gas, filling the caoutchouc bottle

with a solution of sugar of lead in water acidulated with vinegar, and agitating the liquid backwards and forwards, till the bulk of the gas ceases to be diminished. The elevation of the liquid in the tube A, or the diminution of the volume of the gas, indicates the quantity of sulphureted hydrogen gas with which it was mixed.

If the presence of phosphureted hydrogen gas be indicated by the smell, the very same method of analysis is to be followed, only the caoutchouc bottle C is to be filled with a solution of chloride of lime in water, instead of a solution of sugar of lead.

2. Suppose the sulphureted hydrogen or phosphureted hydrogen removed, the next step is to determine the composition of the residue. Ascertain by various trials the volume of oxygen necessary to consume completely a given volume of the gas, and the quantity of carbonic acid formed. From the knowledge of these facts, it is not difficult to infer the gases, and the proportions of which the gaseous mixture is composed.

For example, if a volume of the gas require $2\frac{1}{2}$ volumes of oxygen gas, and produce $1\frac{1}{2}$ volume of carbonic acid, we may conclude it to be a mixture of equal volumes of olefiant gas, and carbureted hydrogen gas. If a volume of it require $1\frac{2}{3}$ volume of oxygen gas, and if the produce be $1\frac{1}{3}$ volume of carbonic acid gas, the gas is a mixture of equal volumes of olefiant gas, carbureted hydrogen, and carbonic oxide. If a volume require its own bulk of oxygen gas, and produce the third of its bulk of carbonic acid gas, we may consider the gas as a mixture of one volume carbureted hydrogen, and two volumes hydrogen.

When olefiant gas is presumed to be present, we may simplify the analysis somewhat by letting up some pure chlorine gas to a given volume of the gas. Chloride of olefiant gas will be formed and separated. If we then remove the excess of chlorine by agitating the gas with some caustic potash, or still better, with lime-water, and note the diminution of bulk, this diminution will indicate the quantity of olefiant gas which was present before the experiment.

When several combustible gases are mixed together, the precision of the analysis is always very much increased, if we can take the specific gravity of the mixed gas. Indeed, if we know the specific gravity, we can in general predict the volume of oxygen gas which will be requisite for complete combustion, and the volume of carbonic acid which will be formed. Suppose the specific gravity of such a mixture to be 0·7645. This being precisely the mean between the specific gravity of olefiant gas and carbureted hydrogen, we conclude, that the gas in question is a mixture of equal volumes of these two gases. We try in consequence whether it will not require for complete combustion $2\frac{1}{2}$ times its volume of oxygen gas, and whether it will not produce $1\frac{1}{2}$ times its volume of carbonic acid gas. If we find this conjecture verified, no doubt can remain that our opinion respecting the constitution of the gas is correct.

Let the specific gravity of our gas be c. Let there be two gases of known specific gravities; and let these specific gravities be respectively a and b; to determine whether our gas be a mixture of these two gases, and in what proportions. Let x and y denote the respective proportions of the two gases, whose specific gravities are a and b. From a well known property of fluids we have $x : y :: c - b : a - c$, hence $x = \frac{(c-b)\,y}{a-c}$. But since $x + y$ must constitute the volume of the gas, which we may call 100, we have $x + y = 100$ and $x = 100 - y$. This gives us the equation $\frac{(c-b)\,y}{a-c} = 100 - y$; from which

$$\text{we deduce } y = \frac{100\,(a-c)}{(c-b)+(a-c)}$$

$$x = 100 - y$$

Suppose we have a gas of the specific gravity 0·8128, which is that of a gas that may be extracted from peat by distillation. Let us see whether this gas may not be a mixture of carbonic oxide, and carbureted hydrogen. The specific gravity of carbonic oxide is $0.9722 = a$; that of carbureted hydrogen $0.555 = b$. In this case $c = 0.8128$.

$$\text{Hence } y = \frac{100\,(a-c)}{(c-b)+(a-c)} = 38{\cdot}2$$

$$x = 100 - y = \frac{61{\cdot}8}{100{\cdot}0}$$

We see that a mixture of 38.2 volumes carbureted hydrogen, and 61.8 volumes of carbonic oxide, will produce a gas of the specific gravity possessed by the gas from peat.

38.2 volumes of carbureted hydrogen will require for complete combustion of oxygen gas 76.4 volumes.
61.8 volumes of carbonic oxide 30.9 volumes.

107.3

So that 100 volumes of the gas will require for complete combustion 107.3 volumes of oxygen gas.

The carbonic acid gas formed by the combustion of 100 volumes of such a mixture, would be 100 volumes.

Now these proportions agree sufficiently well with several of the experiments related by Dr Thomson in his paper *On the Analysis of Gas from Peat* (*Nicholson's Journal*, XVI. 239), to induce us to conclude, that the gas in question is often a mixture of carbureted hydrogen and carbonic oxide, in the proportions here assigned. But the nature of this gas varies with the kind of peat, and with the degree of heat applied to the distillation, as is obvious from the paper just alluded to; and, in many cases, besides carbureted hydrogen and carbonic oxide, hydrogen gas is likewise present.

It would be easy to extend these examples to a much greater length; but the necessary brevity of a supplementary article, obliges us to confine ourselves within as narrow limits as possible. The preceding details, if properly attended to, will enable the pupil to analyse with considerable accuracy, mixtures of gases which are permanent over water. It will be worth the while of those who wish to acquire dexterity in the analysis of gases, to make artificial mixtures of known gases in known proportions, and then to endeavour to detect their composi-

tion by analysis. A few weeks' practice in this way will give him a degree of practical skill, which he could not easily have anticipated, provided all the experiments be conducted with precision. Slovenly experiments, how long so ever continued, never lead to accurate knowledge or to an increase of skill.

4. *Analysis of gaseous mixtures, which require to be examined over mercury.*

We may have over mercury mixtures of the acid gases with each other, or with carbonic acid, sulphureted hydrogen, or chlorine; or with oxygen, azote, hydrogen, or any of the other inflammable gases. A few observations on these cases, which occur but rarely in practice, will suffice.

1. The five acid gases contained in the table, are all absorbed in great quantity by water. If two of them should happen to be mixed together, we are not in possession of methods of separating them from each other, sulphurous acid excepted, which is readily absorbed by peroxide of lead; while the other acid gases have no action on that substance. Our only resource in such a case would be, to cause water to absorb the gaseous mixture,—to saturate both acids with ammonia, and afterwards to throw down each acid by its proper precipitant, and to determine the amount of each by drying the precipitates and weighing them. It seems scarcely necessary to enter into particulars, as such cases are very unlikely to occur, at least to beginners.

2. But nothing is more likely than to have standing over mercury a mixture of carbonic acid gas with sulphurous acid, or muriatic acid, in unknown proportions. Take a determinate volume of such a mixture, and put up into it pieces of common borax. This sub-salt has the property of absorbing the strong acid gases pretty rapidly; but it does not act sensibly on carbonic acid. It will, therefore, absorb the whole of the muriatic acid, or sulphurous acid, and leave the carbonic acid, and the diminution of bulk will enable us to determine the volume of gas which has been withdrawn. When the absorption is at an end, pour the residual gas into another jar, and let up into it a quantity of lime or barytes water. The water will become milky, and the carbonic acid will be absorbed.

The same method will answer if muriatic acid and sulphureted hydrogen gas should happen to be mixed, only instead of lime water we must employ a solution of sugar of lead to absorb the sulphureted hydrogen gas.

3. If we have a mixture of carbonic acid and chlorine gas, we have only to put a given volume of it into a dry jar over mercury, and leave it for 24 hours. The mercury will absorb the whole of the chlorine and leave the carbonic acid.

4. If we have a mixture of an acid gas with oxygen, azote, hydrogen, or any other gas not sensibly absorbed by water, the best mode of proceeding is, to separate the acid gas by means of a solution of caustic potash. The residual gas may then be transferred to the water trough, and examined by the rules already laid down.

The examination of gasses has been greatly facilitated by Gay-Lussac's doctrine of volumes, first explained in the 2d volume of the *Memoires d'Arcueil*, and to be found in all the recent *Treatises on Chemistry*. Every person who wishes to become an expert experimenter on gases, ought to make himself familiarly acquainted with this important branch of chemistry.

Chap. II.—Of Salts.

The salts constitute perhaps the most important set of substances that engage the attention of the practical chemist. It is by their means chiefly that the different acids, alkalies, earths, and metallic oxides, are distinguished from each other. Hence a knowledge of their character, and of the mode of analysing them, is absolutely necessary. A correct analysis of a salt is attended with more difficulty than will at first sight appear. The processes must be as few as possible, and the filtrations and transvasations no more than are absolutely necessary. The difficult part of the process is to wash, dry, and weigh, the precipitates without any loss. We shall divide this chapter into two sections. In the first section we shall give the characters, by means of which, when a salt is presented for examination, its name and composition may be determined; in the second section, we shall give the formulæ for analysing with precision the different genera and species of salts.

Sect. I.—*Of the Characters of the Salts.*

The salts naturally divide themselves into two great orders, according to the nature of the acid which they contain. For one division of the acids is combustible, while another is incombustible. If a salt is presented to us for examination, the first step towards the discrimination of it is to expose it to heat. If it blackens, or if it gives out an inflammable gas, we may consider the salt as belonging to that order which is composed of combustible acids. But if the salt undergoes no change, or if it is merely dissipated without giving out inflammable gas, the salt belongs to the order which is composed of incombustible acids.* We shall therefore divide the salts into orders, and proceed to give the characters of each in succession.

Order I.—*Incombustible Salts.*

These salts may be divided into the following genera, deriving their names from the acid which they contain.

I. Acid gaseous.	I. Acid not gaseous.
1. Carbonates.	1. Sulphates.
2. Sulphites.	2. Nitrates.

* The ammoniacal salts may occasion some ambiguity. But they are easily known by mixing them with caustic potash. Fumes of ammonia are exhaled, at once distinguishable by the smell.

3. Hyposulphites.
4. Nitrites.
5. Chlorates.
6. Hydrosulphurets.
7. Muriates.
8. Fluates.
9. Fluoborates.
10. Hydriodates.

3. Phosphates.
4. Phosphites.
5. Hypophosphites.
6. Iodates.
7. Borates.
8. Arseniates.
9. Arsenites.
10. Chromates.
11. Molybdates.
12. Tungstates.

1. If an incombustible salt be presented to us for examination, reduce a little of it to powder, and throw it into sulphuric acid. If an effervescence take place immediately, or upon the application of a slight heat, the salt belongs to the genera in the first column of the preceding table. *

If the gas extricated be colourless, and have no other smell but a slight pungency, the salt is a *carbonate.*

If the gas has a strong smell of burning sulphur, the salt is a *sulphite.* If the same smell be perceptible, but a quantity of sulphur is deposited, and makes its appearance in the sulphuric acid, the salt is a *hypo-sulphite.*

If the gas disengaged is red, with the smell of nitrous acid, the salt is a *nitrite.*

If the salt assumes an orange colour, and if fumes of chlorine be disengaged, it is a *chlorate.*

If the gas has the smell of rotten eggs, and if it blackens paper, moistened with a solution of sugar of lead, the salt is a *hydrosulphuret.*

If the gas has a strong smell, and if it forms a white vapour when it mixes with the air, the salt is either a *muriate*, *fluate*, or *fluoborate.* If it is absorbed by a small quantity of water, and if the water forms a curdy precipitate, when nitrate of silver is dropt into it, which precipitate is redissolved by an excess of ammonia, the salt is a muriate. If the salt effervesces in a glass vessel, but not in a metallic vessel, and if the glass vessel is evidently corroded, the salt is a *fluate.* If the gas blackens paper when placed in contact with it, the salt is a *fluoborate.*

If the gas is a mixture of sulphurous acid, and vapour of iodine, easily distinguished by its violet colour, the salt is a *hydriodate.*

2. If no effervescence take place, when the salt is mixed with sulphuric acid, even though the mixture be a little heated, we may conclude that the salt belongs to some one of the genera in the second column of the preceding table.

If nitrate of barytes, dropt into the solution of the salt in water, occasions a white precipitate, what is not redissolved, by adding an excess of nitric acid, we may conclude that the salt is a *sulphate.* But if any doubt remains respecting the accuracy of this conclusion, mix together in a flask ten parts of water, one part of the salt, and two parts of nitrate of barytes, and boil the mixture for a few minutes. A white precipitate will fall. Collect this precipitate on a filter, wash it well, dry it, mix it with its own weight of charcoal powder, and expose it for two hours to a strong red heat; if it be sulphate of barytes, it will be converted into a sulphuret, distinguishable by its smell of rotten eggs, and by its being partly soluble in water, and by the solution letting fall a copious white powder, which is sulphate of barytes, when nitric acid is poured into it.

A nitrate is distinguished by the white fumes, with the smell of nitric acid, which it exhales when heated along with sulphuric acid, and by the brilliant combustion which is produced when a little of it is thrown upon a red hot coal.

A phosphate is recognized in this manner, 1. If it be soluble in water, sugar of lead dropt into the solution occasions a white precipitate. Wash this precipitate and dry it, and expose a little of it on charcoal to the action of the blow-pipe. It immediately melts, and, on cooling, crystallizes in the form of a garnet dodecahedron. 2. If it be insoluble in water, expose a little of it to the flame of the blowpipe. If it melt, it will crystallize on cooling into a garnet dodecahedron. If it does not melt before the blow-pipe, it will readily dissolve in muriatic acid, and be again precipitated unaltered by caustic ammonia.

The *phosphites*, when strongly heated, emit phosphureted hydrogen gas, which burns with a flame and a smell that are easily recognizable.

The *hypophosphites* are all soluble in water, and, when strongly heated, it is probable that they likewise will exhale phosphureted hydrogen; though the experiment has not been tried, and hitherto these salts are very imperfectly investigated. They are not likely to come in the way of an experimenter.

The *iodates* are all very little soluble in water. When treated with sulphurous acid, or sulphureted hydrogen, they are decomposed and iodine deposited, easily distinguishable by its colour, and by the property of assuming the state of a violet-coloured vapour, when exposed to heat.

If a *borate* be dissolved in water, and sulphuric acid dropt in, till the solution acquires a perceptibly acid taste, and then be set aside for some hours, a quantity of boracic acid is deposited in scales, easily recognizable by its properties. It is always in our power to obtain the borate in a state capable of dissolving in water. If it be insoluble, we must put it in a flask, with thrice its weight of carbonate of soda, and ten times its weight of water, and boil it for some time; then saturate the whole of the soda with acetic acid, evaporate to dryness, and digest the dry mass in alcohol. The acetate of soda will be dissolved, and nothing will remain but borate of soda, which is soluble in water, and may be decomposed by means of sulphuric acid.

If we mix an *arseniate* or an *arsenite*, with half its weight of *black-flux* or *charcoal* powder, put the mixture into a glass tube, and expose it to a red heat in a crucible filled with sand, a quantity of metallic

* Prussiate of potash effervesces with sulphuric acid; but it gives out an inflammable gas. It is easily known by its yellow colour, its cubic or octahedral form, and its toughness.

arsenic will be sublimed, and coat the upper part of the tube. This arsenic is easily known by its colour, its lustre, its easy combustibility, with the smell of garlic, and the readiness with which it may be sublimed by heat.

If the salt be an *arsenite*, it precipitates sulphate of copper *green*, and is precipitated instantaneously yellow, by hydrosulphet of potash. If it be an *arseniate*, it precipitates sulphate of copper *bluish white*, and no immediate change is produced on it by hydrosulphuret of potash.

If the salt be a *chromate*, its colour is *yellow*. Its solution is precipitated of a very *rich yellow* by acetate of lead, *violet* by the nitrate of silver, and *red* by the protonitrate of mercury.

If the salt be a *molybdate*, on dissolving it in water, and pouring sulphuric acid into the solution, molybdic acid precipitates in the state of a fine powder. If after this we plunge a piece of tin into the solution, the liquid gradually assumes a *blue* colour.

When a *tungstate* is dissolved in water, and the solution mixed with sulphuric, nitric, or muriatic acid, a white flocky precipitate falls. If this precipitate be boiled with a quantity of the acid employed as the precipitant, it assumes a *yellow* colour, and becomes pure tungstic acid.

Having thus ascertained the genus of our salt by means of the preceding characters, the next point is to determine the species of the salt. This is done by determining the nature of the base, which is united in it with the acid.

If the salt be soluble in water, and if the solution is not rendered muddy by the addition of potash, soda, ammonia, or their carbonates, or by the hydrosulphurets, we are entitled to conclude that the base is a fixed or volatile alkali. Mix a little of it with quicklime and a little water, if a strong ammoniacal odour be exhaled, the *base* is *ammonia*. If no odour be exhaled, the *base* is potash or soda. To determine which of the two, drop into the concentrated solution, a solution of tartaric acid till the liquid tastes sensibly sour. If the base be potash, a white and pretty copious crystalline precipitate will gradually fall, consisting of bitartrate of potash. Into another portion of the solution, drop some muriate of platinum. If potash be the base, a yellow precipitate of muriate of platinum and potash will fall. If neither tartaric acid nor muriate of platinum occasion any precipitate, we may consider the base of the salt under examination to be *soda*.

If the salt is soluble in water, but precipitated by an alkali or its carbonate, we must dissolve a portion of it in water, and precipitate it by means of carbonate of potash. The precipitate will consist either of the base of the salt in a state of purity, or of that base combined with carbonic acid.

If the salt be insoluble in water, we must reduce a portion of it to powder, mix it with three or four times its weight of carbonate of potash, and ten or twelve times its weight of water, and boil it for a considerable time in a glass flask. By this method the base is gradually separated, either pure or in combination with carbonic acid.

We must now subject the base thus separated to a chemical examination, in order to determine its nature. To assist the experimenter in drawing his conclusions, we shall state the characters by which these different bases are distinguished.

1. Lime, or its carbonate, is a white powder which dissolves readily in nitric and muriatic acids. This solution does not easily crystallize; but when evaporated, leaves a white matter, easily fusible by heat, and very soluble in water. This solution, if not too much diluted, is precipitated white by sulphate of soda. Though dissolved in 100 times its weight of water, it is copiously precipitated by oxalate of ammonia. The salt formed by uniting lime to nitric or muriatic acid is very soluble in alcohol.

2. Barytes dissolves readily in nitric or muriatic acid. The solutions when concentrated by evaporation yield crystals. The crystals of the nitrate are octahedrons or fragments of octahedrons; those of the muriate are usually four-sided tables. Neither of these salts is soluble in alcohol. When sulphuric acid or a sulphate is poured into a solution of either of these salts in water, a white precipitate falls, which is not redissolved by the addition of nitric acid.

3. Strontian is equally easily soluble in nitric or muriatic acid, and the solutions crystallize with still greater facility than those of barytes in the same acids. The nitrate crystallizes in six-sided tables, with bevelled edges; the muriate in long needles, which, when viewed through a glass, have the form of six-sided prisms. The muriate is soluble in alcohol, and the solution burns with a beautiful red flame. When the solution of nitrate or muriate of strontian is diluted with a great deal of water, sulphate of soda does not occasion an immediate precipitate in it, though it precipitates the same salts of barytes, when equally diluted with water.

4. Magnesia dissolves with great facility in sulphuric, nitric, and muriatic acids. The solution in sulphuric acid crystallizes easily in four-sided prisms with square bases, having an intensely bitter taste; but the nitrate and muriate of magnesia are not easily obtained in a crystallized form. If the crystals of the sulphate of magnesia be dissolved in water, and some sulphate of ammonia be poured into the solution, no change takes place. But if a drop of phosphoric acid be let fall into the mixture, a white insoluble powder immediately falls. Carbonate of magnesia may be completely dissolved by mixing it with water, and causing a current of carbonic acid gas to pass through the liquid.

5. Alumina, when newly precipitated, is easily dissolved by caustic potash held in solution by water. If sal ammoniac be poured into this solution, the alumina is again precipitated in white flocks. Alumina may be dissolved in diluted sulphuric acid by means of heat. If this solution, which is colourless, be mixed with a solution of sulphate of potash, and set aside for some time, transparent octahedral crystals of alum are deposited, readily distinguished by their shape and their taste.

6. Yttria is a white powder, which is not dissolved by digesting it in the caustic alkalies, but it dissolves in liquid carbonate of ammonia. It is easily dissolved in sulphuric, nitric, muriatic, and acetic acids. With these acids it forms crystals, which have a

sweet astringent taste, and redden vegetable blues. A solution of any of these salts is precipitated white by phosphate of soda, carbonate of soda, oxalate of ammonia, and tartrate of potash. It is precipitated likewise by prussiate of potash.

7. Glucina, like alumina, is soluble in the liquid caustic alkalies, and, like yttria, it dissolves in carbonate of ammonia; but its solubility in that liquid is five times greater than that of yttria. Neither the sulphate nor acetate of glucina crystallize. Glucina is thrown down yellow by the infusion of nut-galls, and white by the prussiate of potash.

8. Zirconia is insoluble in the liquid fixed alkalies; but soluble in the alkaline carbonates. It dissolves in nitric, acetic, and muriatic acids; but not in the sulphuric. The nitrate and acetate do not crystallize. The muriate may be obtained in crystals, and is very soluble in water. The solution of muriate of zirconia is precipitated by prussiate of potash, gallic acid, and infusion of nut-galls.

9. *Iron*. There are two oxides of iron; the *black* and the *red*. The first forms crystallizable salts, with sulphuric, muriatic, and acetic acids. These salts have a green colour, and a sweetish, astringent taste. The red oxide dissolves in sulphuric and muriatic acids; the solutions are reddish brown, have an exceedingly strong astringent taste, and do not crystallize. The oxides of iron dissolve readily in muriatic acid. The solution is either green or yellow, according to the acid. Prussiate of potash strikes a dark blue, and infusion of nut-galls a black or a purple, when dropt into this solution. Ammonia throws down the iron in brown flocks. Phosphate of soda occasions a white precipitate. Succinate of ammonia occasions a flesh-coloured precipitate, provided the iron be in a state of peroxide.

10. *Nickel*. Though this metal forms two oxides, yet as only one of them is found united with acids, constituting salts, we may neglect the other here, which is the peroxide, and has a black colour. All the salts containing the protoxide of nickel are of a fine green colour. The oxide itself is grey; but its carbonate (at least while in the state of hydrate) has a light dirty green colour. This oxide (and the observation applies to most metallic oxides) is not soluble in acids without great difficulty, if it has been exposed to a red heat. The hydrated oxide, or still better, the carbonate, on the contrary, dissolves with facility in sulphuric, nitric, muriatic, and acetic acids. The solutions have an intense green colour. The sulphate crystallizes readily, in long needles or square plates. Prussiate of potash, when dropt into these solutions, occasions a milk white precipitate, hydrosulphuret of potash, a black precipitate, infusion of nut-galls no precipitate.

11. *Cobalt*, like nickel, forms two oxides, but the protoxide only is found as a constituent of salts. Its colour is blue, but its carbonate has a shade of red. It dissolves in sulphuric, nitric, muriatic, and acetic acids. The solution has a red colour, provided there be no excess of acid; but the muriatic solution, when there is an excess of acid, is of a deep green colour. Prussiate of potash, when dropt into these solutions, occasions a brownish yellow precipitate, hydrosulphuret of potash, a black precipitate, and the infusion of nut-galls, a yellowish white precipitate.

12. The protoxide of *manganese* forms colourless salts, with acids. The peroxide combines with sulphuric acid, and forms a red solution, which does not crystallize. If the protoxide of manganese be precipitated from a solution by a caustic alkali, it falls down white; but, when the precipitate is exposed to the air, it gradually changes its colour and becomes black. When it is precipitated by an alkaline carbonate, it retains its white colour even when dried. The carbonate of manganese dissolves readily in sulphuric, nitric, muriatic, and acetic acids. The solution is colourless. It is precipitated white by prussiate of potash, white by hydrosulphuret of potash; while the infusion of nut-galls occasions no precipitate.

13. *Cerium* forms two oxides, the *white* and the *brown*, both of which unite with acids, and constitute salts. The salts of the protoxide are colourless, those of the peroxide yellow or orange. When cerium is precipitated from its colourless solutions by an alkaline carbonate, the precipitate is silvery white. Caustic alkalies likewise precipitate it white; and, if the white powder be heated to redness in an open platinum crucible, it becomes brown. Carbonate of cerium dissolves readily in sulphuric, nitric, muriatic, and acetic acids. The solutions have a sweet taste; they are precipitated white by prussiate of potash and hydrosulphuret of potash, by oxalate of ammonia, and tartrate of ammonia, while the infusion of nut-galls occasions no precipitate.

14. The protoxide of *uranium* seems alone capable of uniting with acids. The salts which it forms have a lemon yellow colour. Their solution in water is precipitated blood red by prussiate of potash, brownish yellow by hydrosulphuret of potash, and chocolate brown by infusion of nut-galls. The pure alkalies occasion a yellow precipitate, and the alkaline carbonates a white precipitate, soluble in an excess of the carbonate. The colour of the oxide, after being heated to redness, is greyish black.

15. The oxide of *zinc* forms with acids white salts, which are mostly soluble in water, and the solutions are colourless. These solutions have an astringent taste. Caustic potash occasions a white precipitate, which is redissolved by an excess of the alkali. An alkaline carbonate likewise occasions a white precipitate. A white precipitate is thrown down by prussiate of potash and hydrosulphuret of potash, while infusion of nut-galls occasions no precipitate.

16. Many of the salts of *lead* are insoluble in water. If a little of any of these be placed upon charcoal, and exposed to the action of the blow-pipe, a globule of lead is easily obtained from them. The soluble salts form colourless solutions, which have a very sweet and somewhat austere taste. These solutions are precipitated *white* by prussiate of potash, sulphate of soda, arseniate of potash, oxalate of ammonia, tartrate of potash, and infusion of nut-galls. They are precipitated black by hydrosulphuret of potash. The alkalies occasion a white precipitate, which is redissolved by adding an excess of alkali. The alkaline carbonates occasion a white precipitate, which becomes yellow when exposed to a red heat.

17. As few of the salts of *tin* can be obtained in permanent crystals, they are not likely to occur in the state of dry salts: though solutions of that metal in acid are not unlikely to occupy the attention of the practical chemist. Solutions of protoxide of tin are usually colourless; those of peroxide have often a shade of yellow. They are precipitated *white* by prussiate of potash; *brownish black* by hydrosulphuret of potash, if they contain protoxide; but golden yellow, if they contain peroxide of tin. Corrosive sublimate throws down a black precipitate from solutions of the protoxide, and a white from those containing the peroxide. Muriate of gold throws down a purple precipitate from solutions of the protoxide.

18. The salts of *copper* have a *green* or *blue* colour, unless they contain the protoxide of that metal, when their solution in water is colourless, and the crystals which they form are white. But, as the protosalts of copper are not permanent in the open air, they are not likely to occur to the experimenter except in a state of solution; and such solutions are easily recognised, because, if we expose a little of them to the open air, it soon acquires a green colour. Most of the salts of copper dissolve in water, or become soluble by the addition of nitric or muriatic acid. When ammonia is poured into the solution, it assumes a deep *blue* colour. Prussiate of potash occasions a *red* precipitate, hydrosulphuret of potash a *black* precipitate, and infusion of nut-galls a *brown* precipitate. When a plate of iron or zinc is plunged into a solution of a cupreous salt, the copper is gradually precipitated in the metallic state. Potash precipitates oxide of copper blue, and the precipitate is not redissolved by adding an excess of potash; but ammonia immediately redissolves it, forming a deep blue solution.

19. The salts of *bismuth* are colourless. They are insoluble in water; or at least when we attempt to dissolve them. The acid is separated by water, and the oxide left in the state of white flocks. The salts may be dissolved in acids. From these solutions prussiate of potash throws down a *white* precipitate with a shade of yellow, hydrosulphuret of potash a dark *brown* precipitate, and the infusion of nut-galls a light yellow precipitate.

20. Both the oxides of *mercury* combine with acids. Most of the mercurial salts are white; though some of them have a yellow colour. The solutions of all of them that dissolve in water are colourless. The insoluble salts are easily volatilized by heat in the state of a white smoke. Prussiate of potash, when dropt into a mercurial solution, occasions a *whitish* precipitate, which becomes *yellow* when exposed to the air; hydrosulphuret of potash occasions a *black* precipitate, and infusion of nut-galls an *orange and yellow* precipitate. Potash occasions a black or a brown precipitate, according to the state of oxydation of the mercury. When copper is put into a solution of any mercurial salt, the mercury is precipitated in the metallic state, and tinges the copper white.

21. Few of the salts of *silver* are soluble in water, or capable of being exhibited in the state of crystals. When exposed to the action of the blow-pipe on charcoal they are decomposed, and a globule of silver obtained. Those salts which are soluble in water are colourless, form transparent and colourless solutions, and are exceedingly acrid. Prussiate of potash occasions in them a *white* precipitate, hydrosulphuret of potash a *black* precipitate, infusion of nut-galls a yellow precipitate, and common salt a white curdy precipitate, which becomes dark coloured when exposed to the light. When a plate of copper is put into a solution of silver, the metal is precipitated in the metallic state.

22. Few of the salts of *gold* have been hitherto formed. Hence they are not likely to come in the way of the experimenter. They have a yellow colour. Their solution in water is yellow. They are acrid, and tinge the skin of a deep purple colour, which is indelible. When a plate of tin is put into a solution of gold, the liquid acquires a fine purple colour. When sulphate of iron is poured into it, the gold is precipitated in the metallic state.

23. The salts of *platinum* have scarcely been more studied than those of gold. Those of them that are soluble in water give the liquid a deep brown colour, and render it opaque. Several of the insoluble salts of platinum are yellow or brown, and when exposed to a red heat the platinum is reduced to the metallic state. Neither prussiate of potash nor infusion of nut-galls occasions any precipitate when dropt into solutions of platinum. Sulphureted hydrogen occasions a black precipitate.

24. The salts of *palladium*, when dissolved in water have a fine red colour. Prussiate of potash occasions in these solutions a yellowish *brown* precipitate, hydrosulphuret of iron a blackish *brown* precipitate, and the alkalies an *orange* coloured precipitate. Mercury and the sulphate of iron throw down the palladium in the metallic state. When muriate of tin is dropt into a very diluted solution of palladium, it assumes an emerald green colour.

25. The solutions of the salts of *rhodium* in water are also red. No precipitate is occasioned in them by prussiate of potash, hydrosulphuret of potash, sal-ammoniac, or the alkaline carbonates. But the pure alkalies throw down a yellow powder, soluble in an excess of alkali.

26. The solutions of the salts of *iridium* in water are green; but when concentrated in an open vessel they become red. Prussiate of potash and infusion of nut-galls render the solutions colourless; but occasion no precipitation.

27. *Tellurium*, when in the state of an oxide, is capable both of combining with acids and with bases; so that it acts at once the part of a base and of an acid. The solution of these salts in water is colourless. No precipitate is formed in it by prussiate of potash; but hydrosulphuret of potash occasions a brown precipitate, and the infusion of nut-galls a flaky precipitate of a yellow colour. Zinc, iron, or antimony, precipitate the tellurium in the state of a black powder, which resumes its metallic brilliancy when rubbed.

28. The only salt of antimony at present known is tartar emetic, in which the tartar seems to act the part of an acid. Its solution in water is colourless. It is precipitated *white* by prussiate of potash, and orange-coloured by hydrosulphuret of potash. A plate of zinc or iron speedily throws down a black

powder, especially if there be an excess of acid in the solution.

29. The salts of *titanium* form colourless solutions in water. The alkaline carbonates throw down from these solutions a white flaky precipitate. Prussiate of potash occasions a grass green precipitate. When an alkali is dropt in after the prussiate, the precipitate becomes purple, then blue, and at last white. Hydrosulphuret of potash occasions a dirty bottle-green precipitate. Infusion of nut-galls occasions a bulky blood-red precipitate. When a rod of tin is plunged into a solution of titanium, the liquid around it gradually assumes a fine *red* colour. But a rod of zinc occasions a deep *blue* colour.

Order II.—*Combustible Salts.*

These salts may be divided into the following genera, deriving their names from the acids of which they are partly composed.

1. Acetates.	8. Tartrates.
2. Pyrotartrates.	9. Citrates.
3. Formates.	10. Saclactates.
4. Zumates.	11. Urates.
5. Benzoates.	12. Malates.
6. Succinates.	13. Sorbates.
7. Oxalates.	14. Lactates.

Let us see how these different genera are to be distinguished from each other.

1. An *acetate* is easily recognised by putting a little of it into sulphuric acid, and applying a moderate heat. The fumes of acetic acid are driven off, and they make themselves known by their smell.

2. If a *pyrotartrate* be mixed with sulphuric acid, and distilled in a retort, an acid liquor comes over, and towards the end of the distillation a white sublime rises which is pyrotartaric acid. When the liquid in the receiver is exposed to spontaneous evaporation, crystals of pyrotartaric acid are formed in it. When this acid is dropt into acetate of lead or nitrate of silver no precipitate falls; but needle form crystals gradually make their appearance in the acetate of lead. It occasions a precipitate when dropt into the nitrate of mercury.

3. *Formic* acid agrees with acetic in forming soluble salts with all the bases. But it is destitute of the smell of acetic acid, and the salts which it forms with bases crystallize in different shapes. Thus acetate of copper crystallizes in four-sided pyramids, formate of copper in six-sided prisms. But the properties of the formates have been hitherto investigated so incompletely, that very precise characters of them cannot be laid down. They are not likely to occur to the practical chemist.

4. All the *zumates* are soluble in water. When sulphate of zinc is dropt into their concentrated solutions, a white precipitate falls. None of the other salts form precipitates with the zumates. When zumic acid is obtained in a separate state, it cannot be made to crystallize.

5. Most of the *benzoates* are soluble in water. When nitrate of mercury, or nitrate of tellurium, is dropt into a solution of a benzoate, a white precipitate falls; but persulphate of iron occasions an orange precipitate. If a benzoate be digested with sulphuric acid, the benzoic acid is separated and floats upon the surface. It may be separated, washed with water, and ascertained by its properties; particularly its silky lustre, its solubility in alcohol, its little solubility in water, and its volatility.

6. Many of the *succinates* are soluble in water. If an insoluble succinate be digested with sulphuric acid, the succinic acid is separated, and may be thrown down by diluting the acid with a sufficient quantity of water, and its properties investigated. If into a solution of a succinate, persulphate of iron, as neutral as possible, be dropt, a flesh-coloured precipitate falls. Muriate of barytes occasions a white precipitate, muriate of lime no precipitate.

7. Many of the *oxalates* are insoluble in water. When an oxalate is soluble, muriate of lime throws down a copious white precipitate from the solution. If we digest this precipitate long enough with sulphuric acid, sulphate of lime is formed, and oxalic acid disengaged, which may be crystallized and detected by its taste and its form. When an oxalate is insoluble in water, if we digest it for a sufficient time in a solution of carbonate of potash, part of the oxalic acid will combine with the potash. The potash liquid may now be saturated with nitric or muriatic acids, and then mixed with nitrate or muriate of lime. A white precipitate will fall, which being treated with sulphuric acid, as above described, will betray the oxalic acid which it contains.

8. If into the solution of a *tartrate* we let fall a few drops of potash ley, a granular precipitate falls, consisting of tartar, easily detected by its taste and little solubility in water. Muriate of lime does not occasion an immediate precipitate, when dropt into a tartrate. An insoluble tartrate may be partially decomposed by digestion with carbonate of potash. If the carbonate be saturated with muriatic acid, and then mixed with muriate of lime, and boiled, tartrate of lime falls, which may be decomposed by sulphuric acid, and the tartaric acid being obtained in crystals, is easily recognised by its properties.

9. Most of the *citrates* are soluble in water. These solutions are not precipitated by muriate of lime nor of strontian. But muriate of barytes, and muriate of lead, form white precipitates when dropt into concentrated solutions of the citrates.

10. The *saclactates*, when in solution, are precipitated by the salts of lime, barytes, and strontian; and by the nitrates of silver, mercury, and lead. Hitherto they have been so imperfectly examined, that more decided characters cannot be pointed out. The best mode of proceeding would be to separate the saclactic acid, which could be easily recognised by its properties.

11. The *urates* are nearly all insoluble in water. The best mode of examining them would be to separate the base by means of an acid. The uric acid in that case separates in the state of a white powder. It is characterized by its solubility in liquid potash, and by the fine pink colour which it acquires when heated with nitric acid on a watch glass, just when the whole of the acid is evaporated away.

12. Most of the *malates* are soluble in water, and

the greater number of them refuse to crystallize. Malate of lime is soluble in water; but when the solution is mixed with alcohol, the malate of lime precipitates in the state of a coagulum. This property enables us to convert any malate into malate of lime. We may then separate the lime by means of sulphuric acid, and the malic acid, when obtained in a separate state, may be recognised by its properties. It throws down mercury, lead, and silver, from their respective solutions, in the state of a white powder.

13. If a *sorbate* be soluble in water, the best method of ascertaining the nature of its acid, is to precipitate it by means of sugar of lead, to wash the precipitate, to decompose it partly by sulphuric acid, and to throw down the remainder of the lead by a current of sulphureted hydrogen gas. The sorbic acid, thus disengaged, is a colourless liquid, destitute of smell, but having a strongly acid taste. It does not crystallize, and when evaporated to dryness absorbs moisture from the atmosphere. It precipitates salts of *lead, lime, and barytes*.

14. The *lactates* are all soluble in water. Hardly any of them crystallize, but when evaporated to dryness, have the appearance of gum or mucilage. To obtain the acid in a separate state, the simplest method seems to be to decompose the salt by means of sulphuric acid. Alcohol, digested on the dry mass, will dissolve the lactic acid, and leave the sulphate. Any little portion of sulphuric acid that may exist in the solution, may be removed by cautiously dropping in lactate of barytes. Lactic acid, when thus disengaged, has a brownish yellow colour, a sour taste, but no smell till it is heated, when it acquires a smell somewhat similar to that of sublimed oxalic acid. It is not precipitated from water by acetate of lime, nitrate of silver, muriate of lime, muriate of barytes, nor indeed by any salt whatever.

Sect. II. *Of the mode of analyzing Salts.*

After we have ascertained the genus and species of a salt, by attending to the characters laid down in the preceding section; the next step is to determine the proportions of the constituents of the salt. The analytical processes are greatly facilitated by the knowledge of several general principles, which have been lately ascertained, and which we shall therefore state in the first place.

1. All the acids and all the bases combine with each other in certain determinate proportions; so that a given weight of an acid being taken, we can assign the weight of each of the bases, which is just sufficient to neutralize it. These relative numbers are conceived to represent the weight of an atom or integrant particle of each acid or base. The following table represents these atoms, according to the best information which we at present possess.

1. *Weight of the Atoms of the Acids.*

	Weight of Atom.
Carbonic acid,	2.75
Sulphurous acid,	4.
Hyposulphurous,	3.
Nitrous,	5.75
Chloric,	9.5
Sulphureted hydrogen,	2.125
Muriatic,	4.625
Fluoric,	2.125
Fluoboric,	2.875
Hydriodic,	15.875
Sulphuric,	5.
Nitric,	6.75
Phosphoric,	4.5
Phosphorous,	3.5
Hypophosphorous,	2.5
Iodic,	20.625
Boracic,	2.875
Arsenic,	7.25
Arsenious,	6.25
Chromic,	6.5
Molybdic,	9.
Tungstic,	15.
Acetic,	6.375
Pyrotartaric,	——
Formic,	4.625
Zumic,	——
Benzoic,	15.
Succinic,	6.25
Oxalic,	4.5104
Tartaric,	8.375
Citric,	7.375
Saclactic,	15.125
Uric,	6.357
Malic,	——
Sorbic,	——
Lactic,	——

2. *Weight of the Atoms of the Bases.*

	Weight of an Atom
Ammonia,	2.125
Potash,	6.
Soda,	4.
Lime,	3.625
Barytes,	9.75
Strontian,	6.5
Magnesia,	2.5
Yttria,	5.
Glucina,	3.25
Alumina,	2.125
Zirconia,	5.625
Protoxide of iron,	4.5
Peroxide of do.	10.
Protoxide of nickel,	4.375
Protoxide of cobalt,	4.625
Protoxide of manganese,	4.5
Protoxide of cerium,	6.75
Peroxide of cerium,	14.5
Protoxide of uranium,	16.625
Oxide of zinc,	4.125
Oxide of bismuth,	9.875
Protoxide of lead,	14.
Protoxide of tin,	8.375
Peroxide of copper,	10.
Protoxide of mercury,	26.
Peroxide of mercury,	27.
Oxide of silver,	14.75
Peroxide of gold,	27.875
Peroxide of platinum,	25.625

	Weight of an atom.
Oxide of palladium, -	8.
Protoxide of rhodium, -	16.
Peroxide of rhodium, -	18.
Oxide of iridium, -	7.
Protoxide of antimony, -	—
Protoxide of titanium, -	19.

The inspection of this table shows us that four parts by weight of sulphurous acid are neutralized by six parts by weight of potash, four parts of soda, five parts of yttria, ten parts of peroxide of copper, and so on. The weight attached to the acid is always neutralized by the weight attached to the base. Therefore, if a salt be neutral, and we ascertain the name of the acid and base by which it is composed, the inspection of the preceding tables will enable us to determine the proportions in which its constituents are united.

2. Many acids are capable of uniting in more than one proportion with bases. In such cases we always find, that one atom of base is united with one atom of acid, or with two atoms, or with three atoms, or with four atoms, or, in some rare cases, two atoms of base with three atoms of acid. In general, when there is more than one atom of acid united with one atom of base, the salt has the property of reddening vegetable blues, and it is distinguished by an acid taste. Such salts are called *supersalts;* and they are distinguished from the neutral salts by prefixing to the name of the neutral salt the syllables bi, tri, quadri, &c. indicating the number of atoms of acid united to one atom of base. Thus, *bisulphate of potash* is a compound of two atoms of sulphuric acid with one atom of potash; or, it consists, as we see from the preceding table, of 10 by weight of sulphuric acid united to six of potash. *Quadroxalate of potash* is a compound of four atoms of oxalic acid with one atom of potash; or it consists of eighteen by weight of oxalic acid united to six of potash; or, which is the same thing, it is a compound of three parts by weight of oxalic acid and one part of potash.

In such salts the number of atoms of acid and base united together, can only be determined by analysis: but the analysis is very much facilitated by the knowledge of the general law.

3. Some bases are capable of uniting in more than one proportion with acids. In such salts the same observations apply as in the supersalts. One atom of acid unites with one, two, or more atoms of base. Such salts, if they happen to be soluble in water, which is not always the case, have the property of giving a green colour to vegetable blues, and exhibit other alkaline properties. These combinations are distinguished by the name of *subsalts*. They are named precisely in the same way as the supersalts; but the syllable *sub* is always prefixed to show, that it is the number of atoms of base which is increased, not of the acid. Thus *subbi-borate of soda* is a compound of one atom of boracic acid and two atoms of soda. A much smaller number of subsalts is known at present than of supersalts: whether this be owing to a smaller number actually existing, or to the attention of chemists not having been so much turned to the subsalts as to the supersalts, it would be premature in the present state of our knowledge to determine.

4. Besides the acid and base, many salts contain also a certain proportion of water, usually distinguished among chemists by the name of the *water of crystallization*. It was supposed at first, that no salt can crystallize, unless it contains water as a constituent. But this opinion is not well founded. For many crystallizable salts contain no water whatever. This is the case with *nitre*, with *common salt*, and with *sulphate of potash*. Few of the salts of lead contain any water; yet many of them crystallize with facility, or are found crystallized in the earth. The quantity of water of crystallization varies prodigiously in different salts, and the proportions do not seem reducible under any general law. Some salts, which contain much water of crystallization, are deliquescent, as muriate of lime; others are efflorescent, as sulphate of soda; while others are not altered by exposure to the atmosphere, as alum. The water of crystallization exists always in the same proportion in the same salt; but the number of atoms vary in different salts, from 1 atom, which is the minimum, to 36, or even a greater number of atoms.

5. Sometimes two salts have the property of uniting together in a certain determinate proportion, and of forming a new salt, differing in its properties from both its constituents. Such compounds are usually called *triple* salts; though the term *double* salts would be more appropriate. Thus *alum* is a compound of 3 atoms of sulphate of alumine, and 1 atom of sulphate of potash, together with 23 atoms of water; and *salt of Seignette*, or *Rochelle salt*, is a compound of 1 atom of tartrate of potash, and 1 atom of tartrate of soda. Almost all the salts of ammonia and magnesia, with the same acid, are capable of uniting together, and of forming double salts.

Let us now consider the method of subjecting the salts to a rigid analysis. As the greater number of salts contain an acid, a base, and a quantity of water, we must, in order to solve the problem with accuracy, ascertain the proportion of all these three constituents.

1. If the salt is capable of bearing a red heat, without separating its acid from its base, we can readily ascertain the proportion of water of crystallization, by heating a given weight of the salt in a platinum crucible, and determining the loss of weight. Let it be required, for example, to determine the water of crystallization of *sulphate of soda*. Put into one scale of an accurate balance a platinum crucible, and balance it exactly, by putting the requisite weights in the other scale. Now, put 50 grains of the dry crystals of sulphate of soda into the crucible, and 50 grains in weights in the opposite scale, so as still to maintain the balance. Sulphate of soda contains so much water of crystallization, that when the crystals are heated they melt. Consequently, if the platinum crucible, containing the 50 grains of salt, were suddenly exposed to a strong heat, the salt would boil, and part of it would be driven out of the crucible, which would make the water of crystallization appear greater than the truth. To prevent this loss, the crucible is to be placed upon a

steam bath, or upon a sand bath, not heated above the boiling temperature, and kept in that position, till so much of the water of crystallization is dissipated, that the whole salt is reduced to a solid state. The crucible is then put into a fire, covered with a lid, and the heat raised till the salt is thoroughly red hot, and in a state of fusion. The crucible is now to be withdrawn from the fire, and allowed to cool. When quite cold, it is to be well wiped, and placed again in the balance. It will now be lighter than the weights which formerly counterpoised it in the opposite scale. Add weights till the counterpoise is again restored. These weights will indicate the water of crystallization of the salt. If the experiments be rightly conducted, and the salt in the requisite state, the water of crystallization, in 50 grains of sulphate of soda, will be found to amount to 28 grains, which is equivalent to 56 *per cent.*

2. If the salt is not capable of bearing a red heat without decomposition, it is still possible, in many cases, to determine the water of crystallization. Suppose, for example, that the acid can bear a red heat without volatilization, but that the base is ammonia, which is usually driven off by a very moderate heat. Let the salt, for instance, be phosphate of ammonia, or tungstate of ammonia. Weigh out 50 grains of it, and put it into a small retort. This retort must be fitted to a very small receiver, containing a saturated solution of caustic potash. Before the experiment begins, the retort, and likewise the receiver, must be accurately weighed, and their weights noted down. Heat is then gradually applied to the bottom of the retort, till the salt becomes visibly red hot. The whole is then weighed a second time. The loss of weight sustained by the retort is equivalent to the weight of the base of the salt, and to that of the water of crystallization which the salt contained. The receiver will have increased in weight, and the increase will be just equal to the water of crystallization of the salt. This increase subtracted from the loss of weight sustained by the retort, will give the weight of ammonia which the salt contained.

Suppose 50 grains of acetate of potash to be presented to us for examination, and that it is required to determine the water of crystallization which this salt contains. The potash, in the present case, is capable of bearing a red heat, but not the acetic acid. We may proceed in this way: Mix the 50 grains of acetate of potash with an excess of sulphuric acid in a platinum crucible, and expose the mixture at first to a low heat, which is to be very slowly raised till the crucible is heated intensely red hot. The heat of a common fire will not be found sufficient to dissipate the excess of acid, unless it be urged by a pair of bellows. By this process the acetate of potash is changed into sulphate of potash. Ascertain the weight of this new salt, $\frac{6}{11}$ths of it are potash. Thus we obtain the weight of the potash contained in the 50 grains of acetate of potash. Let this weight be $= a$. Now, the weight of an atom of acetic acid is 6.375, that of potash is 6. Hence, we have $6 : 6.375 :: a :$ quantity of acetic acid in 50 grains of acetate of potash $= x$. From this proportion we obtain $x = \frac{6.375\,a}{6}$. Now, it is obvious, that $a + x$ is the amount of the potash and acetic acid in 50 grains of acetate of potash. If we subtract this sum from 50, the remainder will give us the water of crystallization contained in the salt.

Many of these salts, though incapable of bearing a red heat without decomposition, may be exposed to the heat of boiling water without injury. And in many cases, this temperature is sufficient to remove the whole or nearly the whole of the water of crystallization. Then in many cases this method may be applied with success.

4. When both of the constituents of a salt are volatile, and when it cannot be exposed even to a moderate heat without volatilization, in such a case we are unable at present to determine the water of crystallization directly. Such is the case with acetate of ammonia. But even in this case we are not without resource; though the only methods which can be followed require uncommon skill and every possible precaution. If we dissolve the acetate of ammonia in water, and add potash to the solution (noting the quantity) till we have just driven off the whole of the ammonia, and saturated the acetic acid; knowing the weight of potash employed, we can hence determine the weight of the acetic acid saturated. Knowing the weight of acetic acid, we can deduce from the preceding table the weight of ammonia requisite to saturate it. The weight of the acetic acid being added to that of the ammonia, and the sum subtracted from that of the original quantity of acetate of ammonia experimented on, the remainder will be the weight of the water of crystallization which that salt contains.

II. The second step in the analysis is to determine the weight of acid contained in a determinate weight of the salt. Three different modes are pursued, according to the nature of the acid. We must give an account of each.

1. When the acid is such that it forms an insoluble precipitate with some particular base. In that case we precipitate the acid by means of a salt containing the requisite base, wash and dry the precipitate, and ascertain its weight. This (as the composition of the precipitate is known) enables us to determine the weight of acid which the salt contained.

To give an example: Sulphuric acid is completely precipitated from every soluble salt by mixing the solution of the salt with muriate of barytes. Sulphate of barytes is a compound of five sulphuric acid and 9.75 barytes, so that $\frac{5}{14.75} = 0.339$ of the precipitate, supposing it well washed and dried in a red heat, is sulphuric acid. Let it be required to determine how much sulphuric acid exists in fifty grains of crystallized sulphate of soda. Put the fifty grains of the salt into a cylindrical glass vessel, about twelve inches in length and four inches in diameter. Pour over the salt twenty times its weight of distilled water, and stir the liquid occasionally with a glass rod, till the salt is completely dissolved.

Have in a clean phial a solution of muriate of barytes in distilled water. Pour a little of this liquid into the solution of the sulphate of soda, and then stir the solution with a glass rod. It will become immediately milky. Continue to add muriate of barytes as long as the milkiness appears to increase. Then leave the mixture for an hour or two till it has deposited the whole of the sulphate of barytes formed, and till the liquor has become clear. Let a drop of muriate of barytes fall into it; if it does not become white, we may conclude that the whole sulphuric acid has been precipitated. If it becomes white, we must add an additional quantity of muriate of barytes, and stir the liquor again with a glass rod. When it has become clear again, we try it once more with muriate of barytes. In short, muriate of barytes must be added till the supernatant liquor is not affected by any farther addition of that salt. When this is accomplished, allow the glass cylinder to remain at rest till the whole of the precipitate is deposited, and the liquid is perfectly transparent. Then draw off the clear liquor, either by means of a small syphon, or by the little glass instrument represented in fig. 16. It consists of a glass hollow ball, terminating both above and below in a glass tube. The undermost part of the lower tube is drawn out into a capillary fineness. The method of using this little instrument, usually called a *sucker*, is to plunge the capillary end into the liquid, and, applying the mouth to the other extremity, to suck in the liquor by the lips till the ball is filled with it. Then applying the tongue rapidly to shut the end in the mouth, the sucker is lifted out, and its extremity being put into another glass vessel, the tongue is withdrawn, upon which the liquid again runs out. This may be repeated till the whole colourless liquid is removed. Considerable promptitude is requisite in applying the tongue. For if any of the liquid be allowed to run out before the sucker be withdrawn, it will agitate the precipitate, and, rendering the whole liquor muddy, will prevent you from proceeding with the process till it has had time to settle. Another form of this little instrument is represented in fig. 17. But it is only when salts are analyzed upon a smaller scale than fifty grains, that the sucker can be employed with advantage.

When the clear liquid has been thus withdrawn as completely as possible from the precipitate, without running the hazard of losing any portion of the powder, a quantity of distilled water is to be poured into the glass, and the precipitate is to be stirred with a glass rod till it is well mixed with the water. A paper filter, formed by folding a sheet of blotting paper into the quarto form, and then with a pair of scissors cutting off the corner farthest from the centre into the segment of a circle, so as to give the folded paper the appearance represented in fig. 18.; it is obvious that if this paper were unfolded, it would have a circular shape. There is a paper prepared on purpose for filtering, and sold by apothecaries under the name of filtering-paper. But nothing answers so well as *printing* paper, procured from the mills before it has been sized. The filter is to be put in a glass funnel, placed upon a wooden stand, with a vessel below it to receive the liquid. A plan and elevation of such a stand, with funnels in it, is represented in fig. 19. The number of funnels in the stand may be increased at pleasure. In the figure, three only are represented. Four is the usual number.

The liquid containing the precipitate is to be poured upon the filter, and care must be taken to wash out the whole precipitate from the cylindrical glass with distilled water, and to pour the whole upon the filter, without allowing a single drop to escape. When the whole water has run through the filter, an additional quantity of distilled water is to be poured upon the precipitate. This must be continued till the water which passes through the filter is perfectly tasteless, and till it ceases to render muddy a solution of sulphate of soda, when a drop of it is let fall into that liquid. When this is the case, it is a proof that the sulphate of barytes on the filter is sufficiently washed. When the filter ceases to drop, it is to be removed from the funnel and placed upon some folds of blotting paper. The corners cut off from the paper, in preparing it for a filter, will answer the purpose. It may now be dried in the open air, or what is still better, by putting it upon a *steam-bath*, which is a large square plate of iron heated by steam. When dry, it is to be laid upon a table till it has become quite cold, and till it has imbibed the quantity of moisture which the air of the room supplies. The filter then, with the sulphate of barytes which it contains, is to be exactly weighed in an accurate balance. We then, by means of a blunt platinum spatula, or ivory spatula, loosen the precipitate from the paper. We then put as much of this precipitate as we can into a platinum crucible of known weight, and we ascertain the weight of sulphate of barytes thus introduced. Let the weight be a. The platinum crucible is now to be put into a fire, covered with its lid, and exposed for half an hour to a good red heat. When cold we weigh it again. The loss of weight indicates the quantity of water driven off from the sulphate of barytes by the red heat. Let the weight of the sulphate of barytes thus dried be b. Take the dry filter and rub off the whole of the remains of the precipitate with a dry cloth, then weigh the filter again. The weight of the filter subtracted from the original weight when the filter contained the sulphate of barytes, gives us the whole weight of the sulphate of barytes before it was exposed to a red heat. Let this weight be c. Let the weight of the whole sulphate of barytes, after it has been exposed to a red heat (supposing it possible to make the experiment), be x; then we have $a:b::c:x$, and, of course, $x = \frac{bc}{a}$.

In the case of sulphate of barytes, it is possible to separate the whole of the precipitate from the filter. But, in many cases, this cannot be done. In such cases, we remove as much of the precipitate as we can; we then measure the size of the filter, and burn it to ashes in a platinum crucible, and ascertain the weight of these ashes. A filter made from the same paper, and of the same size, is likewise to be burnt to ashes, and the weight of these ashes ascer-

tained. This last quantity being subtracted from the first, gives us the quantity of precipitate that had remained attached to the filter.

When the precipitate left on the filter has the property of absorbing moisture, as is often the case, we must weigh the filter while still warm. But this cannot be done in the usual way, because the filter would be constantly absorbing moisture and becoming heavier. To prevent this, procure a glass tube shut at one end, and having a cork covered with sealing wax fitted to the open end. This tube must be of such a size as to contain the filter when properly wrapt up. The weight of the tube and its cork should be written upon it with a diamond. In such a tube the filter may be weighed conveniently.

Having thus ascertained the weight of the sulphate of barytes, we have only to multiply that weight by 0.339; the product will be the quantity of sulphuric acid contained in the sulphate of soda under analysis.

There is no accurate method of determining, by analysis, the weight of the soda contained in the sulphate of soda; but when we know the weight of water and of sulphuric acid which the salt contains, we may infer the weight of the soda; since that weight, added to the two others, will constitute the sum total of the weight of the salt analyzed. Thus, suppose we find 50 grains of sulphate of soda to yield

Water -	28 gr.
Sulphuric acid	12.2
	40.2

It is obvious that 9.8 grains are wanting to make up the total weight 50; hence we infer, that the soda in 50 grains of sulphate of soda weighs 9.8 grains.

We may take another example of an analysis of a salt, conducted in exactly the same way; and we shall select common salt, as very convenient for our purpose.

Common salt contains no water of crystallization; but it is seldom destitute of water mechanically mixed with it; therefore, before subjecting it to analysis, it is proper to expose it for some time to a red heat in a platinum crucible; then weigh out 50 grains of it, and dissolve them in twenty times their weight of water.

The solution is to be mixed with a solution of nitrate of silver in distilled water, as long as any precipitate falls. The precipitate, when well washed and dried, is a compound of chlorine and silver, in the proportion of 4.5 chlorine to 13.75 silver; so that $\frac{4.5}{18.25}$ of the precipitate, or 0.2465 of it is chlorine. Hence the weight of the precipitate, multiplied by 0.2465, gives us the weight of chlorine in 50 grains of common salt; this weight, subtracted from 50, leaves the weight of the sodium, which is the other constituent of common salt.

Phosphoric acid may be completely precipitated from the phosphates, by muriate of lime. When the precipitate is properly washed and dried, $\frac{100}{180.5}$ or 0.554 of its weight is phosphoric acid.

The fluoric acid is likewise precipitated by muriate of lime; but the quantity of fluoric acid indicated by a given weight of precipitate, has not been ascertained with the requisite degree of accuracy.

2. When the acid is of such a nature that it can be completely precipitated from the base with which it is combined, by means of some other acid, and thus obtained in a separate state, the simplest method is, to precipitate it, wash it, and dry it. It is easy then to ascertain its weight, and thus to determine the proportion of acid which a given weight of the salt subjected to analysis contains. In this way may the acids in all the salts, whose acid is insoluble in water, or nearly so, be ascertained. Thus the acid of the *borates* may be precipitated by sulphuric acid; molybdic and tungstic acids may be precipitated by nitric acid; arsenious acid, in many cases, may be precipitated by sulphuric acid or muriatic acid; uric acid may be precipitated by acetic acid; saclactic acid may be precipitated by muriatic acid.

3. When the acid is of such a nature that it may be destroyed by heat, while the base remains unaltered, the method is to deprive the salt, in the first place, as completely as possible, of its water of crystallization. A given weight of it is then put into a platinum crucible, and exposed to a heat, at first low, but gradually raised to such a degree of intensity as to enable it to dissipate the acid completely, and to leave nothing behind but the base. Suppose it was required to determine the quantity of acid in a given weight of oxalate of lime. The oxalate is first made as dry as possible by exposing it for several hours to a temperature equal to that of boiling water. It may be afterwards left for 24 hours under the exhausted receiver of an air-pump, in which there is placed a wide shallow vessel, containing sulphuric acid. The salt thus dried is put into a platinum crucible, and exposed at first to a red heat. The temperature is then raised to whiteness, to dissipate the carbonic acid formed and united to the lime in the first part of the process. The residual lime being now weighed, and its weight subtracted from the original weight of the dried salt, the remainder indicates the weight of oxalic acid which was originally united to the lime.

In this way may combinations of the vegetable and animal acids, with various acids, be analyzed. When the acid is united to a metallic oxide, easily reducible to the metallic state, as the protoxide of lead, in order to obtain accurate results, it is necessary to dissolve the residual oxide in acetic acid. That portion of lead which has been reduced to the metallic state during the process will remain unacted upon. This quantity must be weighed, and $\frac{1}{13}$th of its weight must be added to it. This additional weight being united to the weight of oxide left, after the decomposition of the salt, will constitute the true weight of the oxide, which being subtracted from the original weight of the salt, will give the quantity of acid with which the oxide of lead was originally united in the salt.

III. The last step in the process is the determination of the weight of base with which the acid is united. In almost all the salts, except those of potash, soda, and ammonia, the base may be thrown down by means of these alkalies, or their carbonates. And the precipitate being washed and thoroughly dried, indicates the weight of base which the salt contained.

In many cases it is more correct to employ an alkaline carbonate as a precipitant than a pure alkali. In this way lime, barytes, and strontian, are very conveniently thrown down from their combination with acids. The precipitates thus obtained consist not of the pure earths, but of the earths united to carbonic acid. So that a portion of the weight of the precipitate must be subtracted before the true weight of the base is known. In carbonate of lime the carbonic acid amounts to $\frac{275}{637.5}$ or 0.431 of the whole; in carbonate of barytes it is $\frac{275}{1250}$ or 0.22; in carbonate of strontian to $\frac{275}{925}$ or, 0.297. Hence if we multiply the weights of the respective precipitates by these numbers, the products obtained, subtracted from the original weight, will give us the true weight of lime, barytes, or strontian, contained in the salt analysed.

In some cases the oxide which constitutes the base of the salt, changes its state after its precipitation. Thus the *protoxide of iron* thrown down from any of the proto-salts of iron, cannot well be dried without being converted into *peroxide of iron*. Now, when 4.5 of protoxide of iron is converted into peroxide, its weight is increased to 5. Let the weight of peroxide obtained be a, and that of the protoxide required be x. We have $5:4.5::a:x$. Hence $x = \frac{4.5\,a}{5}$; or it is nine-tenths of the peroxide.

We have already, in a preceding part of this chapter, pointed out the method of determining the quantity of ammonia, or of potash, or soda, which exist in a salt.

Chap. III.—Of Mineral Waters.

The analysis of waters consists in determining the different substances, whether saline or gaseous, which waters hold in solution. The processes are minute and tedious, and require very great precision. We shall divide this chapter into two sections. In the first section we shall point out the method of determining the quantity and nature of the gaseous contents of mineral waters: in the second section we shall point out the mode of detecting the saline contents, and of ascertaining the amount of each.

Sect. I.—*Of the Gases contained in Waters.*

Suppose a mineral water is presented for analysis, and we are required to determine whether it holds any gaseous matter in solution; and if it does, to ascertain the nature and proportions of the gaseous contents. It is proper to observe, in the first place, that the gases held in solution in waters, are of so fugitive a nature, that we cannot expect to detect them in any water, unless we examine it fresh from the source. If the water has been brought from a distance, though in well stopped bottles, we may be pretty certain that the gaseous constituents, or at least a considerable part of them, have made their escape during the transit of the water. If the water be fresh drawn, the method of proceding is this: Have a retort, the capacity of which is known. Fill it with the water in question. Plunge its beak under a jar filled with mercury on the mercurial trough, and then by means of a lamp cause the liquid in the retort to boil as long as any gas is extricated from it. The gas, as it is extricated, passes into the glass jar along with the vapour of the water; and after the process is at an end, its quantity may be easily estimated, as the jar into which it has passed must be supposed divided into cubic inches and tenths. The bulk of the water being known, and that of the gas extricated being known, we have the proportion of gas contained in the water under examination. Thus, suppose that the experiment is made upon 25 cubic inches of water, and that the gaseous product measures 2.5 cubic inches: we infer, that every 100 cubic inches of the water contains 10 cubic inches of gas.

The only gases hitherto observed in mineral waters (at least capable of being separated by the above method) are,

1. Oxygen.
2. Azote.
3. Carbonic acid.
4. Sulphureted hydrogen.

Those waters that contain sulphureted hydrogen are easily distinguished by the smell of that gas which they exhale, by their property of blackening silver, and of striking a black when mixed with acetate of lead.

The waters which contain carbonic acid gas have an acidulous taste, a sparkling appearance, like champaign or bottled small beer. When dropt into lime water they render that liquid milky. If we attempt to dissolve acetate of lead in them, the solution becomes milky; but the addition of a little acetic acid renders them perfectly transparent.

For the mode of determining the quantities and species of these gases when extricated, we refer to the first chapter of this article.

Sect. II.—*Of the Saline contents of Waters.*

To determine the proportion of salts contained in a mineral water, the simplest, easiest, and most accurate mode, is to put a determinate weight of the water (1000 grains, or 10,000 grains, according to circumstances) into a wide and flat platinum, or silver capsule; to place the capsule upon a steam-bath, so regulated that the heat shall never exceed 180°. In this position the aqueous part will gradually evaporate away insensibly, without ever boiling, so that there will be no risk of any of the liquid being thrown out of the vessel. The saline contents will at last remain, forming a very thin crust upon the surface of the capsule. The capsule may now be removed to a sand-bath, and exposed to a heat sufficiently high to drive off all the water of crystallization. The weight of the platinum capsule being already known, we have only to weigh it carefully. When the salt is attached to it the increase of weight

indicates the quantity of saline matter furnished by the water under examination.

Upon the saline contents thus separated, pour a quantity of distilled water, equal to that in which the salts were originally dissolved. If the whole saline matter be dissolved in this water, the probability is that the saline matter has not been altered by its crystallization. But if a portion remain undissolved, as is usually the case, then we may conclude, as Dr Murray has very ingeniously suggested, that some of the salts have mutually decomposed each other, when brought into a concentrated state by the evaporation, and that salts have been formed which did not exist in the mineral water before its evaporation.

Almost the only salts combined in water are the carbonates, sulphates, and muriates of soda, lime, magnesia, and iron. The first point is to determine the different acids and bases present; the second to ascertain the relative weight of each.

Carbonic acid is ascertained by the water containing the carbonate forming a precipitate with muriate of barytes, which precipitate redissolves in nitric acid with effervescence.

When sulphuric acid is present, muriate of barytes occasions a precipitate not redissolved by nitric acid.

When muriatic acid is present, nitrate of silver produces a white curdy precipitate, which becomes dark-coloured when exposed to the light, and which is dissolved by means of caustic ammonia.

Lime is detected by the white precipitate produced in the water by oxalate of ammonia. Magnesia is precipitated by ammonia, or by dropping into the water, first carbonate of ammonia, and then phosphoric acid. The presence of iron is detected by the water containing it striking a black with infusion of nut-galls, and a blue with prussiate of potash.

The formula suggested by Dr Murray (*Transact. Royal Society of Edinburgh*, VIII. 259) is fully as accurate a means of analysing waters as any other, and seems to be easier of execution. It has been followed for many years by the writer of this article; but with one or two modifications, which seem calculated to guard against mistake. Supposing the gaseous ingredients of a mineral water to be ascertained, and the weight of its saline ingredients determined, we may proceed to the accurate analysis of it, as follows:

Measure out a determinate volume of it (as 50 or 100 cubic inches), and evaporate it, in an open vessel, down to one third. Divide this evaporated liquid into three equal portions. Precipitate the first portion by muriate of barytes; wash the precipitate, collect it, dry it at a red heat, and weigh it; digest it in nitric acid, dry it, and weigh it again. The loss of weight indicates the quantity of carbonate of barytes which the precipitate contained. The residual weight is sulphate of barytes; the carbonic acid in the water is equivalent to 0.22 of the weight of the carbonate of barytes; the sulphuric acid to 0.339 of the weight of the sulphate of barytes.

Precipitate the second portion by means of nitrate of silver; wash the precipitate, dry it, and fuse it in a platinum capsule, previously weighed. By weighing the capsule, containing the fused chloride of silver, the weight of the precipitate may be ascertained. The fourth part of this weight is equivalent to the weight of the muriatic acid, contained in the portion of water precipitated.

Precipitate the third portion by oxalate of ammonia; wash and dry the precipitate; expose it to a red heat, in a platinum crucible; pour on it some dilute sulpuric acid; digest for some time, then evaporate to dryness, and expose the crucible to a pretty strong heat; weigh the sulphate of lime thus formed, 0.453 of its weight, indicates the quantity of lime in the portion of water precipitated.

Pour into the same third portion of the water thus freed from its lime, a portion of carbonate of ammonia, and let phosphoric acid fall into it, drop by drop, as long as any precipitate continues to fall. This precipitate being washed, dried, and exposed to a red heat, is phosphate of magnesia. 0.357 of the weight of this salt is equivalent to the weight of the magnesia contained in the water.

If the water be a chalybeate, a portion of it equal to one of the three preceding portions, must be taken and mixed with a solution of benzoate of ammonia. The precipitate being washed, dried, exposed to a red heat, and weighed, nine-tenths of its weight indicates the weight of protoxide of iron contained in the water.

By the preceding steps, the weight of all the substances contained in the water will be ascertained, except the soda. To know the amount of it, we cannot do better than follow exactly Dr Murray's formula. Evaporate a portion of the water to one-third. Precipitate the carbonic and sulphuric acids by muriate of barytes, taking care not to add any excess of the precipitant. Throw down the lime by oxalate of ammonia, and the magnesia by means of carbonate of ammonia and phosphoric acid. Then evaporate the liquid thus treated to dryness. A quantity of common salt will remain, which must be exposed to a red heat; 0.4 of this weight indicates the sodium contained in the bulk of water employed. And 0.4 sodium is equivalent to 0.53 of soda.

It seems hardly requisite to mention some other substances that occasionally make their appearance in mineral waters. Silica is a common constituent, very easily obtained in a separate state. We have only to evaporate a portion of the water to dryness, and redissolve the saline residue in distilled water. The silica will remain undissolved, and will betray itself by its insolubility in acids, and its easy fusibility into a transparent glass, with soda, before the blow-pipe.

Chap. IV.—Of Metals.

Nothing is more likely to occur to the young analyst for investigation than alloys of various metals in various proportions. Before such alloys can be successfully analysed, it is necessary to be acquainted with the properties of all the metals in a pure state, because methods of separating them from each other can only be deduced from a knowledge of these properties. It will be requisite, therefore, to divide this chapter into two sections. In the first section, we shall point out the method of ascertaining the name of any pure metal presented for examination: in the

second, we shall give the formulas for analysing the most important alloys.

SECT. I.—*Method of ascertaining the Names of Metals.*

The metals at present known amount to 33; all of which might be easily recognized, by determining their specific gravity, and observing their colour and hardness. The following table exhibits these properties, as far as they are at present known:

	Colour.	Sp. Gravity	Hardness.
Potassium -	White	0.865	4
Sodium -	White	0.972	4
Calcium -	White	——	—
Barium -	White	——	—
Strontium -	White	——	—
Magnesium -	White	——	—
Manganese -	Grey	8.013	8
Iron - -	Grey	7.8	9
Zinc - -	White	7.1908	6.5
Copper -	Red	8.895	7.5
Nickel -	White	8.82	8.5
Cobalt -	Grey	8.7	6
Uranium -	Grey	9.	8
Palladium -	White	12.148	9
Tin - -	White	7.299	6
Antimony -	White	6.712	6.5
Molybdenum -	White	8.611	—
Mercury -	White	13.568	—
Arsenic -	White	5.763	5
Tellurium -	White	6.115	—
Bismuth -	White	9.822	7
Lead - -	Blue	11.352	5.5
Silver - -	White	10.510	7
Tungsten -	White	17.4	9
Chromium -	White	5.9	9
Titanium -	Yellow	——	—
Columbium -	Grey	5.61	8
Cerium -	White	——	—
Osmium -	Grey	——	—
Gold - -	Yellow	19.361	6.5
Platinum -	White	21.5313	8
Rhodium -	White	10.694	9
Iridium -	White	18.68	9

But as it may not be always in the power of the experimenter to ascertain these properties with accuracy, we shall point out the method of determining each metallic body from its chemical properties. Suppose a metal presented for investigation, and that it is required to determine its name: 1. The first thing to be done is, to put a portion of it into pure water. If an effervescence take place, and the metal dissolve in the liquid, we may conclude that it is an alkaline metal; or one of those in the first division of the preceding table. Now, as none of the alkaline metals, except potassium and sodium, has been hitherto obtained in a permanent state, we may conclude that our metal is one or other of these two. Saturate the alkali thus formed, by the solution of the metal in water, with sulphuric acid, and evaporate the liquid till it deposites crystals. It is very easy to distinguish whether these crystals be sulphate of potash, or sulphate of soda. Sulphate of potash forms very hard small crystals, which are fragments of the pyramidal dodecahedron. They require a great deal of water to dissolve them; and are not altered by exposure to the atmosphere. Sulphate of soda crystallizes in six sided prisms, terminated by dihedral summits, and the sides of the prism are channeled longitudinally. When these crystals are exposed to the air, they speedily effloresce, and fall to powder.

The metal called *manganese* likewise effervesces in water. But instead of dissolving, it is converted into a green-coloured oxide. The process is much slower with this metal than with potassium or sodium. But as manganese has not been applied to any useful purpose, and as it speedily oxydizes in the air, there is but little chance of its coming in the way of the practical chemist, at least for analysis.

2. If the metal undergoes no sensible alteration in water, we may conclude, that it is neither manganese nor an alkaline metal; but some one of the others in the preceding table. The next thing to be done is, to put it into sulphuric acid, previously diluted with twice or thrice its bulk of water. If it effervesces and dissolves in this liquid, the metal is either *iron* or *zinc*. If it is not acted on sensibly by the acid, it is one or other of the remaining metals in the table.

The solution of *iron* in sulphuric acid is readily distinguished from the solution of zinc in the same acid. The zinc solution is *colourless*; that of iron light-green. Infusion of nut-galls strikes a *black*, when poured into the iron liquid; but it produces *no change* upon the liquor of zinc. Prussiate of potash throws down iron *blue*, but zinc *white*. When an alkali is dropt into the solution of iron, a greenish white precipitate appears in flocks, which soon becomes dark green, and finally changes to reddish yellow; but an alkali throws down the solution of zinc chalk white, and the colour undergoes no subsequent change.

3. Supposing the metal to undergo no change in dilute sulphuric acid, the next step of the investigation will be to put it into dilute nitric acid. If it effervesce with that acid, either cold, or when slightly heated, it will be one or other of the following fourteen metals:

1. Copper, nickel, cobalt, uranium, palladium.
2. Tin, antimony, molybdenum.
3. Mercury, arsenic, tellurium.
4. Bismuth.
5. Lead, silver.

We have divided these fourteen metals into five sets, each of which are characterized by certain peculiarities, which are easily recognized.

(1.) The five metals, constituting the first set, when dissolved in nitric acid, tinge that liquid of some colour or other; while the solutions of all the others are colourless, like water.

The solution of *copper* is *blue*, or *greenish blue*. When potash or soda is dropt into the liquid, a blue deposite falls, which is not redissolved by adding an excess of alkali. A few drops of ammonia occasion a bluish white precipitate, which is redissolved by adding an excess of the ammonia, and the liquid assumes a fine purplish blue colour. Prussiate of potash occasions a red precipitate, and a plate of iron plunged into the liquid is speedily covered with a coating of copper.

The solution of *nickel* is *grass-green*. When ammonia is poured into it in sufficient quantity, it becomes blue. Potash or soda throws down a green precipitate. Prussiate of potash occasions a milk-white precipitate. A plate of iron when put into it does not throw down any metal.

The solution of *cobalt* is *violet red*. The alkalies throw down from it a blue coloured precipitate. When this precipitate is mixed with borax, and fused before the blow-pipe, it forms a violet blue glass. The prussiate of potash occasions a brownish yellow precipitate. Infusion of nut-galls produces a yellowish white precipitate. A plate of iron throws down no metal.

The solution of *uranium* is *yellow*, and when concentrated by evaporation, it yields lemon yellow crystals. The alkalies throw down a yellow precipitate from this solution; prussiate of potash, a blood red precipitate; and infusion of nut-galls, a chocolate-coloured precipitate. A plate of iron does not throw down any metal.

The solution of *palladium* is *red*. When protosulphate of iron is dropt into it, the palladium is precipitated in the metallic state. Prussiate of potash throws down an *olive*; the alkalies an *orange* precipitate. Muriate of tin renders the solution opaque, by throwing down a brown precipitate; but if the liquid be sufficiently diluted, it assumes a fine emerald green colour.

(2.) The three metals, tin, antimony, and molybdenum, which constitute the second set in the preceding series, have this peculiarity, that when treated with concentrated nitric acid, they are not dissolved, but merely converted into white or yellowish white powders. We have it not, therefore, in our power to examine the liquids when these metals are the subjects of experiment. But the characters of tin, antimony, and molybdenum, are so different, that they are very readily distinguished from each other.

Tin is a ductile metal, and it is characterized by a creaking noise which it emits when bent, or when squeezed between the teeth. It dissolves with effervescence in muriatic acid. When this recent solution is mixed with muriate of gold, a beautiful purple powder precipitates, well known by the name of *purple of Cassius*. Corrosive sublimate, dropt into the recent solution of tin in muriatic acid, occasions a black precipitate; but when dropt into the permuriate it throws down a white precipitate. Prussiate of potash produces a white precipitate. Hydrosulphuret of potash occasions a brownish black precipitate when dropt into the protomuriate of tin; a golden yellow when dropt into the permuriate. Antimony is a very brittle metal, and easily reduced to a fine powder in a mortar. It dissolves with great rapidity in nitro-muriatic acid. The solution has a yellowish colour. When water is poured into it the liquid becomes milky, and a copious white precipitate falls down. Prussiate of potash, when dropt into the nitro-muriatic solution of antimony, occasions a white precipitate, while hydrosulphuret of potash occasions an orange-coloured precipitate. When a plate of iron is put into the liquid, a black precipitate gradually falls.

Molybdenum is a brittle metal; but so infusible, that it has been hitherto obtained only in grains. The white powder into which it is converted by nitrid acid, possesses the properties of an acid. When diffused through water, it reddens vegetable blues, and combines very readily with the alkalies. If a plate of zinc or of tin be put into water through which this powder is diffused, the powder gradually assumes a blue colour.

(3.) The three metals, mercury, arsenic, and tellurium, form colourless solutions in diluted nitric acid; but they are easily distinguished from the other three metals, that likewise form colourless solutions, by their great volatility.

Mercury being always in a fluid state at the common temperature of the atmosphere in this country, and being the only known fluid metal, cannot be confounded with any of the other metallic bodies, even by the most inexperienced experimenter. Hence it would be needless to point out its chemical properties when in solution.

The properties of arsenic are scarcely less striking than those of mercury. It is a very soft and brittle metal. If we put it into a retort and expose it to heat, it is completely volatilized, though the temperature does not exceed 356°. It is deposited in crystals in the throat of the retort. When laid upon a red hot iron in the open air, it burns with a pale blue flame, and evaporates in a white smoke, having the smell of garlic.

Tellurium is at present so scarce a metal, that it is not likely to come in the way of a chemical analyst, at least in the metallic state. It is very brittle and volatile. When heated before the blow-pipe it burns with a blue flame, and evaporates in a white smoke, having the smell of radishes. When an alkali is dropt into the solution of tellurium, in nitric acid, a white precipitate appears, which is redissolved on adding an excess of alkali. Prussiate of potash occasions no precipitate, infusion of nut galls a yellow precipitate, and hydrosulphuret of potash a brownish black precipitate. A plate of iron throws down the tellurium in the state of a black powder, which resumes the metallic lustre when rubbed.

(4.) Bismuth, the only metal belonging to the fourth set of the above series, dissolves very rapidly in nitric acid of moderate strength. The solution usually crystallizes in the course of twenty-four hours. If the solution of bismuth in nitrid acid be diluted with a great deal of water, it becomes milky, and a copious precipitate of a white powder, which is a hydrate of bismuth, falls.

(5.) The fifth set in the preceding series contains only lead and silver, two metals so different from each other, and so familiarly known to every one,

that it seems scarcely necessary to point out the chemical differences between them.

The solution of lead has a sweet taste, accompanied with a certain degree of astringence. When evaporated sufficiently, it crystallizes in octahedrons or tetrahedrons of a white colour, opaque, but having considerable lustre. When these crystals are exposed to a red heat a yellow oxide remains, which readily melts when heated, and flows into a glass of a dark-reddish yellow colour, and a considerable degree of hardness. Nitrate of lead is precipitated white by sulphuric acid and the sulphates, white by prussiate of potash, white by infusion of nut-galls, and black by hydrosulphuret of potash.

The solution of silver, on the contrary, in nitric acid, has an acrid taste, and constitutes one of the most corrosive substances known. When sufficiently concentrated by evaporation, it crystallizes in transparent plates, which melt easily when heated, without undergoing decomposition. The solution of nitrate of silver is precipitated in white flocks, like curd, by common salt. This precipitate becomes speedily dark-coloured when exposed to the light. It is dissolved by ammonia. The solution of protosulphate of iron, poured into nitrate of silver, precipitates the silver in the metallic state.

4. If the metal resists the action of diluted nitric acid, even when assisted by heat, the next step in the investigation will be to expose it to a red heat, in contact with air, in a platinum crucible. If by this process it is converted into an oxide, we may conclude it to be one or other of the following six metals;

Tungsten, chromium, titanium, columbium, cerium, osmium.

When tungsten is calcined in the open air, it is converted into a yellow-coloured powder, which possesses the properties of an acid, and is known by the name of tungstic acid. If we mix tungsten with its weight of nitre, and calcine the mixture in a crucible till the nitric acid is decomposed, the residual mass is almost completely soluble in water. Muriatic acid, when dropt into this solution, throws down a white precipitate, which, when boiled in an excess of acid, becomes yellow, and possesses the characters of molybdic acid.

Chromium, in the metallic state, is so scarce, that it is not likely to come in the way of the experimenter. By calcination it is converted into a green powder, scarcely soluble in acids. If chromium be mixed with its own weight of nitre, and kept for half an hour at a red heat in a crucible, a yellowish-coloured mass is obtained, which dissolves in water, and the solution has a yellow colour. Nitrate of silver, dropt into this liquid, throws down a purple precipitate; nitrate of lead a brilliant orange precipitate; and nitrate of mercury a red precipitate.

Titanium has hitherto been scarcely ever obtained in the metallic state, so that it cannot well offer itself for the investigation of the practical chemist; it is hardly necessary, therefore, to point out its characters. When calcined in contact with air, it assumes a blue colour. It dissolves in nitro-muriatic acid by the assistance of heat. The solution, when freed as much as possible of all excess of acid, has a pale yellow colour. Infusion of nut-galls throws down from it a blood red precipitate. Prussiate of potash throws down a grass green precipitate mixed with brown. When an alkali is dropt in after the prussiate, the precipitate becomes purple, then blue, and, at last, white. When a rod of tin is plunged into the nitro-muriate of titanium, the liquid around it gradually assumes a fine red colour; a rod of zinc, on the other hand, occasions a deep blue colour.

Columbium has been reduced to the metallic state by Professor Berzelius. When calcined it undergoes an incipient combustion, and is converted into a greyish white matter; but it cannot, by this method, be completely oxydized. When mixed with nitre, and thrown into a red hot crucible, a feeble detonation takes place. A snow-white mass is thus obtained, which must be digested in muriatic acid, to separate the potash. The white substance remaining after this treatment is columbic acid. When fused with eight times its weight of carbonate of potash, it forms a compound which dissolves in water. Muriatic acid throws down the columbic acid in the state of a white hydrate. Neither prussiate of potash nor hydrosulphuret of potash occasion any precipitate; but infusion of nut-galls throws it down orange, provided there be no excess either of acid or alkali in the liquid.

Cerium having not hitherto been obtained in the metallic state, except in very minute portions, cannot come under the examination of the experimental chemist. It dissolves in nitro-muriatic acid, when assisted by heat. The solution, when freed as much as possible of its excess of acid, has a sweet taste. It is precipitated white from this solution by prussiate of potash, hydrosulphuret of potash, tartrate of potash, oxalate of ammonia, and the alkalies. Infusion of nut-galls occasions no precipitate. When the precipitate by oxalate of ammonia, or tartrate of potash, is calcined in a platinum crucible, it assumes a reddish brown colour.

When osmium is heated in the open air, the oxide evaporates as it forms, exhaling a very strong odour, and acting very powerfully upon the eyes. If osmium be mixed with its own weight of nitre, and heated in a retort, a white sublimate rises, having a strong odour, a caustic taste, and soluble in water. The solution is colourless, but becomes blue when mixed with the infusion of nut-galls. When a rod of zinc, or a quantity of alcohol or ether, is poured into the solution, the osmium precipitates in white flocks.

5. If the metal under examination is neither altered by water, sulphuric acid, nitric acid, or calcination in the open air, it must be one or other of the following:

Gold, platinum, rhodium, iridium.

Gold is easily known by its yellow colour and its great specific gravity. It dissolves with great facility in nitro-muriatic acid. The solution has a yellow colour, a caustic taste, and tinges the skin purple. Protomuriate of tin precipitates it purple. Protosulphate of iron precipitates the gold in the metallic state. When ammonia is poured into the solution a yellow precipitate falls in flocks, which, when

dried, assumes the form of a brown powder, and fulminates loudly when exposed to heat.

Platinum has a white colour and a higher specific gravity than any other metal. It dissolves in nitro-muriatic acid, provided the acids of which the liquid is composed be as concentrated as possible. The solution is dark brown and opaque. Sal ammoniac throws down a fine yellow precipitate from this liquid. When the precipitate is exposed to a red heat, it is converted into metallic platinum. The nitro-muriate of platinum is neither precipitated by prussiate of potash, nor infusion of nut-galls; but sulphureted hydrogen throws down a black precipitate.

Rhodium is a white brittle metal, which, when pure, is not dissolved by nitro-muriatic acid, nor by any acid compound whatever. It may be obtained dissolved in acids, when the solution is facilitated by the presence of certain other metals. The solution, in such cases, is red, and it is not affected by prussiate of potash, hydrosulphuret of potash, or infusion of nut-galls. The pure alkalies throw down a yellow powder, soluble in excess of alkali.

Iridium dissolves in concentrated nitro-muriatic acid, but with difficulty. When ammonia is poured into the concentrated solution, a great number of small brilliant crystals are deposited, of so deep a purple, that they appear black, and capable of communicating an orange red colour to a great quantity of water. This colour is destroyed by dropping into the liquid protosulphate of iron, or sulphureted hydrogen, or by putting into it a rod of iron, zinc, or tin.

Sect. II.—*Method of Analysing some of the principal Alloys.*

It would be needless to lay down formulas for the analysis of all the conceivable alloys of the metals, as the greater number of them could never be of any practical utility. We shall satisfy ourselves with noticing such of them as are applied to purposes of utility, and which, therefore, must frequently offer themselves to the view of the practical chemist.

1. *Silver Coins.*

The modern European silver coins are all alloys of silver and copper, in very different proportions, according to the country where they are issued. Some idea of the proportion of copper in these coins may be formed from the following table, drawn up by Dr Thomson, from a very extensive series of analyses of these coins. (Nicholson's *Journal*, XIV. 409.)

	Alloy per cent.		Weight of Silver, that of the Copper being 1.
British,	7.5	-	12.5
Dutch,	8	-	11.5
French,	9	-	10.1
Austrian,	9.5	-	9.5
Sardinian,	9.5	-	9.5
Spanish,	10.5	-	8.5
	15.5	-	5.5
Portuguese,	11	-	8
Danish,	12	-	7.3
Swiss,	21	-	3.8
Russian,	24	-	3.6
Hamburgh,	50	-	1

Besides silver and copper, it is not uncommon also to find traces of gold in silver coin.

To analyse a silver coin, we may put it (previously washed with soap and water, and well wiped, to remove any grease with which it may be covered) into about four times its weight of strong and pure nitric acid, previously diluted with three or four times its weight of water. It dissolves rapidly, with effervescence. The gold remains undissolved in the state of a fine powder. It may be collected on a watch glass, well washed, carefully dried, and its weight ascertained. It will never be found to exceed a minute fraction of a grain.

The nitric acid solution contains the silver and the copper, which last metal gives it a blue colour. The silver is to be precipitated by means of common salt, and the precipitate being well washed, dried, and exposed to a heat sufficient to fuse it, is to be weighed with the requisite accuracy. $\frac{13.75}{18.25}$ or 0.753 of this weight is silver.

Into the liquid thus deprived of its silver, pour a quantity of sulphuric acid, sufficient to decompose the nitrate of copper which it contains. Evaporate the liquid nearly to dryness, and dissolve the whole residue in distilled water. Put a rod of zinc into the liquid, and allow it to remain for 24 hours. The whole of the copper will be precipitated in the metallic state. Wash the zinc rod, to separate any copper which may adhere to it. Allow the copper to settle to the bottom of the vessel. Decant off the colourless liquid, and replace it by distilled water, acidulated with muriatic acid. An effervescence will take place, owing to the solution of a portion of zinc which had fallen down along with the copper, and there is usually, at the same time, a quantity of nitrous gas exhaled. The copper may now be collected upon a watch glass, well washed, dried, and weighed.

If this analysis has been rightly conducted, the weights of the gold, silver, and copper, added together, ought to equal the weight of the original coin subjected to experiment.

In some of the silver coins of the Roman emperors, as of Alexander Severus, and Gordianus, there exists a little lead along with the preceding constituents. When such coins are dissolved in nitric acid, the oxide of the lead remains mixed with the gold. The gold may be separated by digesting the residue in nitro-muriatic acid. We may then boil the residual oxide of lead in muriatic acid, and evaporate to dryness. The muriate of lead thus formed being dried, heated, and weighed, $\frac{13}{17.5}$ or 0.743 of its weight will be lead.

In the copper coins of Gallienus, we find a quantity of tin. When the coin is dissolved in nitric acid, the oxide of tin remains undissolved. It may be dissolved in muriatic acid, precipitated in the metallic state by a rod of zinc, and weighed.

When copper coins contain lead as well as tin, which is the case with the Chinese coins, the process of analysis is the same, only the lead must be precipitated from the nitric solution by means of sulphate of soda. The white precipitate being well washed

and dried, is to be weighed: $\frac{13}{19}$ths or 0.684 of its weight is equivalent to the lead.

2. Pewter.

What is called *pewter* in this country was perhaps originally pure tin, but it has long been customary to alloy the tin with some other metal. Lead constitutes by far the most common alloy; but antimony is said, also, sometimes to exist in pewter. But, whether pewter be an alloy of tin and lead, or of tin and antimony, the process of analysis is nearly the same. Put the pewter, to be analysed, into a phial containing three or four times its weight of concentrated nitric acid, and allow the liquid to remain in contact with the alloy, at a boiling temperature, till all action on it has ceased. Let us suppose the pewter, in the first place, to be an alloy of tin and lead.

When the nitric acid has ceased to act upon the pewter, we must put the whole into a porcelain evaporating dish, and evaporate nearly to dryness. Distilled water is then poured upon the white mass, the whole is digested for some time, and then thrown upon a filter. The white powder which remains on the filter is a perhydrate of tin. It must be washed with water till that liquid passes off tasteless, then dried, and exposed to a red heat. It thus acquires a yellow colour, and is peroxide of tin $\frac{7.375}{9.375}$ or 0.786 of the weight of this oxide indicates the tin in the portion of pewter subjected to analysis.

The watery solution contains the nitrate of lead. It must be all collected, and concentrated by evaporation. Being mixed with sulphate of soda, the lead is thrown down in the state of sulphate of lead. This sulphate, being edulcorated, washed, and exposed to a red heat, and weighed, gives the weight of the lead contained in the pewter. For $\frac{13}{19}$ or 0.684 of dry sulphate of lead is lead.

When the pewter consists of tin and antimony, nitric acid converts it into a white hydrate, without dissolving any of it. But, if we wash away the nitric acid, and substitute muriatic acid in its place, the whole white matter is dissolved. If water be poured into the solution, the antimony is precipitated in the state of a white hydrate. Collect this hydrate, dry it, and expose it to a red heat. It is now deutoxide of antimony. $\frac{100}{123.7}$ or 0.808 of this oxide is equivalent to the weight of the antimony in the pewter. The tin may be precipitated from the muriatic acid in the metallic state by a rod of zinc, and its weight ascertained.

3. Brass.

Brass is a compound of copper and zinc. There are two varieties of it. The first, or British brass, composed of an atom of copper, and an atom of zinc. The second, or Dutch brass, is composed of two atoms of copper, and 1 atom of zinc. The mode of analyzing both varieties is the same.

Dissolve the brass in diluted nitric acid, and pour into the solution a considerable excess of liquid potash. The copper is precipitated in the state of a blue hydrate, while the zinc is retained in solution by the potash. Expose the hydrate of copper to a red heat, and weigh it; four-fifths, or 0.8 of its weight is equivalent to the weight of the copper contained in the brass.

Pour a slight excess of sulphuric acid into the liquid containing the zinc in solution. Then add carbonate of potash, as long as any precipitate falls. The white precipitate, which is carbonate of zinc, is to be well washed, dried, and exposed to a red heat. By this exposure, it is converted into oxide of zinc. $\frac{4.125}{5.125}$ or 0.8048 of this oxide is equivalent to the weight of the zinc contained in the brass.

If the brass happen to contain lead, we can detect the presence of that metal by dropping sulphate of soda into the nitric acid solution. The sulphate of lead will precipitate, and we can deduce the quantity of lead from it by the rule already laid down.

If the brass contains iron, its presence will be indicated by dropping prussiate of potash into the nitric acid solution; a blue precipitate will fall, or at least the liquid will assume a blue tinge. The peroxide of iron may be precipitated by the cautious addition of ammonia to the nitric acid solution, previously rendered neutral by evaporation to dryness, and solution in distilled water. This peroxide being washed, dried, exposed to a red heat, and weighed, $\frac{3.5}{5}$ or 0.7 of its weight is the iron which existed in the brass.

4. Bronze and Cannon Metal.

Bronze is an alloy of copper and tin. This alloy was used by the ancients for making into cutting instruments. It is often called *brass* in English. The mode of analysis is nearly similar to those already described.

The bronze is to be dissolved in concentrated nitric acid, and the action of the acid is to be promoted towards the end of the process, by raising it to the boiling temperature. The copper will dissolve, while the tin will remain in the state of peroxide. The weight of the two metals thus separated from each other may be determined by the rules already laid down in this section.

The analysis of bell-metal is to be conducted exactly in the same way as that of bronze. But bell-metal, besides copper and tin, often contains zinc, and sometimes silver.

When bell-metal is treated with nitric acid, the tin remains in the state of a perhydrate. The copper, zinc, and silver are dissolved. Precipitate the silver by means of common salt, and determine its quantity by the rules above laid down. The nitric acid solution now contains only copper and zinc, which may be obtained in a separate state by the method pointed out for analysing brass.

5. Silver and Lead.

Lead, when first obtained from its ores, is almost always alloyed with a certain quantity of silver. This metal renders the lead much harder and less ductile. It is, therefore, always removed, when the quantity

of silver contained in the lead is sufficient to defray the expence of the process. The proportion of silver is always determined by the process called *cupellation*. As this process is employed likewise to ascertain the purity of silver and gold, and to obtain silver in a state of purity for the purposes of the silversmith, it will be worth while to describe it in this place. It may be performed either in a common reverberatory furnace, or in the muffle of a wind furnace, heated to the temperature of about 27° Wedgewood.

Cupels are small, flat, porous cups, weighing about 200 grains, and composed of bone ashes, well calcined, pounded, and washed. This powder is mixed with a proportion of fern ashes, and is moistened and beat with mallets into an iron mould. If a metallic alloy be placed into such a cupel, composed of two metals, one of which is easily oxydized by heat and air, while the other undergoes no alteration, and if the oxide be easily fusible into a liquid glass, this liquid oxide will make its way through the pores of the cupel, while the metal, not having any affinity for the cupel, will remain behind in the state of a metallic button.

Place the cupel in the furnace, and bring it to the requisite degree of heat; then place upon it a certain determinate quantity of the lead to be subjected to cupellation. The lead speedily melts; becomes covered with a coat of oxide; exhales fumes, and undergoes a considerable agitation, which, by renewing the surface, promotes the process of oxydation. In this way the whole of the lead is gradually converted into an oxide; this oxide melts, and is absorbed by the cupel. As the oxydation proceeds, the bulk of the lead diminishes, and it leaves a reddish brown trace upon the surface of the cupel. The surface, which was at first flat, becomes evidently convex, and brilliant points may be seen on it, which are continually increasing in size. At last, when the lead is nearly quite removed, the brilliant points disappear, the metallic button becomes covered with an iridescent pellicle, which disappears instantaneously, and the brilliant metallic lustre is again restored. The process is now finished. But care must be taken not to cool the silver button too suddenly, lest a portion of it should be squeezed out and lost by the too rapid congelation of the external coating. The button of silver is now to be weighed, and its weight indicates the proportion of silver which the lead under examination contains.

Silver may be freed from copper, or any other metal with which it is alloyed (except gold and platinum), by the same process. The quantity of lead employed must increase with the proportion of alloy which the silver contains; varying from about twenty times to four times the weight of the silver, according to its purity or impurity. Indeed, the proportions of lead may be much smaller than are usually indicated in books, provided the process be conducted with the requisite skill. Place the lead upon the cupel, and when it is melted, wrap up the silver in a piece of paper, take it up with a pair of forceps, and place it over the middle of the lead. The two metals incorporate almost instantaneously. The phenomena of the cupellation are precisely similar to what has just been stated. The oxide of lead carries along with it the whole of the copper, and leaves the silver in a state of considerable purity.

6. *Gold and Silver*.

Gold and silver are separated from each other by means of nitric acid. The alloy is laminated and put into hot nitric acid. The silver dissolves, but the gold remains behind in the state of a powder, which is easily fused into a button and weighed. It is to be observed, however, that it is not possible by this method to separate the whole of the silver from the gold, unless the weight of the first metal considerably exceeds that of the second. When this is not the case, we must, in the first place, fuse the alloy with such a quantity of silver as will make the amount of the silver in the alloy three times that of the gold. We then laminate this alloy, and treat it with nitric acid. Knowing the portion of silver added to the alloy, it is easy to determine its composition.

When gold is alloyed both with silver and copper, as is often the case with gold coins, the first process followed is to remove the copper by the cupel. The silver is then separated from the gold by means of nitric acid, adding previously the requisite proportion of silver.

We might now give the processes for separating the metallic oxides, when they happen to be mixed or united together in various proportions. But the methods already given for the metals will apply likewise to the oxides. It is necessary, however, to observe, that the greater number of oxides lose their power of dissolving in acids, if they have been exposed to a red heat. To restore their solubility, we must mix them with two or three times their weight of potash, or carbonate of potash, and expose them to a red heat. The potash may then be washed away with water, and the oxides will remain in a state of solubility in acids. Or if the potash has the property of dissolving the metallic oxide, we may precipitate the oxide by saturating the potash with an acid, and then pouring an alkaline carbonate to the solution, or by passing at once a current of carbonic acid gas through the potash solution.

Chap. V.—Of Stones.

The term *stone* is applied to the indurated masses of which the surface of the earth is composed. These masses have been carefully examined by mineralogists, and have been found composed of about 164 different species of minerals, to which names have been assigned. These minerals, with a very few exceptions indeed, may be considered as *salts*, often chemically united with each other, or mechanically mixed in various proportions. As we are not in possession of any method of distinguishing the chemical combinations from the mechanical mixtures, and do not even know any means of ascertaining, whether a mineral subjected to analysis be pure or impure, much less progress has been made in ascertaining the chemical nature of stones, than might have been expected, from the great labour and abilities bestowed on the investigation. The subject,

therefore, still claims the closest attention of the practical chemist, and on that account it will be proper to give a pretty minute account of the best method of analysing these bodies with accuracy.

The acids found in stones are chiefly silica, sulphuric acid, carbonic acid, phosphoric acid, fluoric acid, boracic acid, arsenic acid, and tungstic acid. The bases are alumina, lime, barytes, strontian, magnesia, and, in some rare cases, yttria, glucina, zirconia. Oxide of iron is a common constituent of stones. In some rare instances oxides of manganese, copper, chromium, and nickel, are found in them.

We shall divide this chapter into two sections. In the first section we shall give an account of the apparatus requisite for analysing stones; and, in the second, lay down the formulas necessary to be followed in conducting the analysis. Considerable practice is necessary to enable us to conduct the different processes without loss, or with the least possible loss. We should endeavour always to make the number of processes as few as possible; for the risk of loss and of error obviously increases with the number of processes through which our mineral has to go.

Sect. I.—*Of the Apparatus for Analysing Stones.*

Before a stone can be subjected to analysis, it is generally necessary to reduce it to an impalpable powder. We must, therefore, be provided with two mortars, which are appropriated to that purpose. The first of these is of steel, and is well known to jewellers by the name of the *diamond mortar*, because it is employed for pounding diamonds. It consists of three distinct pieces of polished steel, possessing a considerable degree of hardness. The first of these constitutes the bottom of the mortar. It is a circular piece of steel, about an inch thick. The top is flat and polished, only it has a circular ring raised a little above it, and the flat circular space within this ring is about an inch and a quarter in diameter. The second piece is a hollow cylinder of steel, of such a size as to fill exactly the circular space within the ring of the first piece, to which it is fitted by grinding. This cylinder is about two inches high, and the diameter within is about an inch. The third piece is a solid steel cylinder of the same length as the hollow cylinder, into which it is fitted by grinding, and it has a bulb on the top. The stone, previously broken into small pieces, is reduced to a pretty fine powder in this mortar. A little of it is put into the hollow cylinder, the solid cylinder is fitted in, and by a blow with a hammer it is smartly struck against the bottom part. By this blow the fragment is crushed, the pieces of the mortar are now removed, and the powder which lies on the bottom piece is carefully poured into a glass capsule. By proceeding in this way the stone is reduced to a coarse powder.

To convert this into an impalpable powder an agate mortar is employed. Plate LXIX. Fig. 20, exhibits an outline of this mortar. *a* is a section of it, *b* a profile of it, and *c* the pestle which is also of agate. These mortars are made at Oherstein in Germany, but may be purchased both in London and Paris, and cost half a guinea. They are about three inches in diameter, and about an inch and a half or two inches thick. These mortars are sufficiently hard for grinding in them the hardest stony bodies. But when the mineral to be pounded is very hard, as sapphire, spinell, &c. a portion of the mortar is always ground down at the same time. It is necessary to keep an account of this portion. This is done by weighing the mortar before and at the end of the process. The loss of weight which it has sustained, is the portion of the mortar which has been ground down and mixed with the mineral to be analysed. As agate mortars are composed almost entirely of silica, we have only to subtract from the weight of silica which we obtain from the mineral, the quantity which has been rubbed from the mortar. The remainder will be the silica really contained in the mineral. Suppose that, while pounding a mineral in our mortar, the mortar undergoes a loss of twenty grains, and that we obtain forty grains of silica by the subsequent analysis. It is obvious that our mineral will really contain only twenty grains of silica, the other twenty grains having been rubbed off the mortar. Mortars of rock crystal or flint might be likewise employed. But those of rock crystal would be more expensive than the agate mortars, without possessing any advantage over them: and flint is so very easily broken, even by a slight blow, that a mortar made of it would be apt to go to pieces in the very act of pounding.

To pound the mineral successfully in an agate mortar, some precautions must be taken. We must put only a small quantity (not more than a few grains in weight) into the mortar at once. The pounding is performed by rubbing the pestle against the bottom of the mortar; and we must continue the friction till all feeling of grittiness has disappeared, and till the powdered mineral adheres together in the form of a cake. As it is of the utmost consequence not to lose a particle of the mineral during the pounding, the mortar must be placed upon a sheet of clean paper, and we must be careful not to drive any of the mineral out of the mortar by incautious pounding. When the whole mineral is reduced to powder we must weigh it again. If the operation of pounding has been properly performed, the powder should be equal to the weight of the mineral and of the portion rubbed off the mortar both together.

When the mineral is reduced to an impalpable powder, the next step of the process is usually to mix it with twice or thrice its weight of caustic potash, or carbonate of soda, according to circumstances, and to expose the mixture to a red heat for an hour, in a metallic crucible. A crucible is a small vessel used by chemists and various artists, for exposing bodies to heat. It is made of clay, of black lead, of iron, silver, and platinum. Its shape is nearly conical, with the point of the cone cut off. The narrowest part constitutes the bottom and the widest the top. It is usually furnished with a lid composed of the same materials with the crucible itself. Its size varies from an inch or less to several feet in height, according to the purpose for which it is to be used. For the analysis of stony bodies, we should be provided with crucibles of fine silver and of platinum. The size may be about two inches in height,

and an inch and a half in diameter at the mouth. Silver is the least acted upon by pure potash; but platinum is upon the whole preferable to silver, because it is not so easily fused, and because it is not injured, as silver is, when put into a common fire of pit-coal. For the sulphur which pit-coal usually contains, speedily combines with the silver and destroys it. When a silver crucible is to be used, it must be inclosed within a common clay or black-lead crucible, and care must be taken not to expose it to a heat sufficient to melt the silver. There is little risk of this in a common fire, if we do not urge it with bellows.

When the mixture of alkalies and stone has been exposed for an hour to a red heat, we must take it off the fire and allow it to cool. Upon inspecting this hot matter, we are enabled, from the appearance which it assumes, to draw some conclusions respecting the constitution of our mineral. If the mixture has melted completely, we may be sure that the mineral either consists entirely of silica, or at least contains a considerable proportion of that earth. If it has not melted, the probability is, that a great deal of alumina is present in the mineral. If the mixture while hot has a brownish red colour; but becomes green on cooling, we may be sure that iron is present. Grass green indicates manganese, and yellowish green chromium.

The next set of vessels required are dishes, into which the mixture is to be put, after being softened with water, in order to be dissolved in muriatic acid, and afterwards evaporated to dryness, or nearly so, upon a sand bath. The most convenient vessels for this purpose are those which are made of porcelain. In this country they are known by the name of Wedgewood's evaporating dishes. They are circular, and shaped somewhat like a saucer, only they have a spout at one side for the convenience of pouring out their contents, and they have no circular rim round the bottom. In the inside they are glazed, but destitute of glaze on the outside. The size varies from one inch in diameter to a foot or more. The most convenient, upon the whole, for mineral analyses, are about six inches in diameter, and about $2\frac{1}{4}$ inches deep. The French chemists employ porcelain vessels, which have the shape of hemispheres, and are all glazed, both within and without, except the bottom, which is to be applied to the hot sand. These vessels are not so apt to crack as those of Wedgewood; but the glaze is more apt to crack in all directions. When this happens, it is impossible to make them completely clean; so that the same dish cannot be employed long for the analysis of minerals, without the risk of error from that cause.

The remainder of the apparatus employed in the analysis of minerals, does not require a particular description. The filters, the test-glasses, &c. are precisely similar to those described in a preceding part of this Article.

Sect. II.—*Method of analysing Stones.*

Let us suppose a stone to be presented for analysis. The first step of the process is to drop a fragment of it into muriatic acid. If it effervesces in the acid and dissolves, we may infer that it is an earthy carbonate: if it is not sensibly acted on by the acid, the process of analysis will be more complicated. We shall first give the mode of analysing the more complicated stones. They are for the most part silicates, or combinations or mixtures of silicates.

I.—*Simple Stones.*

Great pains should be taken in selecting the specimen for analysis. It should always be as pure as possible, and should be selected for the purpose by a skilful mineralogist. The chemist, before he begins the analysis, should ascertain the specific gravity of the specimen, and write down a mineralogical description of it from actual observation. This serves as a kind of testimony of the nature of the mineral, after it has been destroyed by the analysis.

The quantity taken for analysis may be about 50 grains. When more than this is employed, the analysis becomes very tedious. The time is shortened in proportion to the smallness of the quantity examined. If we work upon a grain or two only, we may ascertain the nature of the constituents in an hour or two. But 50 grains enable us to determine the weight of each constituent with sufficient exactness, while it is so great as to render it unlikely that any one of the constituents should be overlooked, without our perceiving the oversight.

The first step of the analysis is the reduction of the mineral to an impalpable powder, in the way described in the last section. We then weigh out fifty grains of it, mix it with twice or thrice its weight of carbonate of soda, or pure potash, and expose it for an hour to a red heat in a platinum crucible. When the mineral contains a great proportion of silica, carbonate of soda answers just as well as caustic potash, while it is much cheaper. Klaproth, who first introduced the use of caustic potash in mineral analysis, always employed that alkali in solution in water, and gradually evaporated the mixture to dryness. He conceived that this rendered the mixture of the potash with the mineral more intimate, and of course facilitated the mutual action. In most cases litharge may be substituted for potash with advantage. It succeeds even when the mineral contains a considerable proportion of alumina. But we must be sure that the litharge is quite free from lead in the metallic state, otherwise it would injure the platinum crucible.

When the crucible is removed from the fire, and has become cold, we must wipe it quite clean on the outside with a cloth, and then, placing it in the middle of a Wedgewood evaporating dish, fill the crucible with distilled water. After standing some hours covered with the water, the mixture at the bottom of the crucible will be partly softened. Stir it up with a platinum spatula; pour off the water containing all the softened part of the mixture into the Wedgewood dish; fill up the crucible with distilled water again, and let it stand some hours as before. In this way you must proceed till the whole of the mixture has become soft, and has been washed out of the crucible.

Muriatic acid must now be poured into the watery

liquid in the Wedgewood dish. An effervescence takes place, because the alkali has absorbed carbonic acid during the preceding process, which is driven off as it dissolves in the muriatic acid. You continue to add muriatic acid till all effervescence has ceased, and till the whole of the matter has dissolved.

Some minerals which contain little silica, and a great deal of alumina, will not be rendered quite soluble by heating them with an alkali. In such cases a portion of insoluble matter remains, upon which the muriatic acid has no action. This is a portion of the mineral in its original state. To render it soluble we must repeat the heating with an alkali, softening with water, and adding muriatic acid till we obtain a complete solution. Five or six repetitions of these processes may in some cases be requisite. With such minerals it is better to employ litharge, or borax, or phosphoric acid, than potash or soda. We will then obtain a complete solution by one process, which will greatly diminish the risk of error. If we employ too little alkali, it may happen that we do not obtain a complete solution in muriatic acid, even when our mineral contains a sufficient quantity of silica. The insoluble matter in such a case will be pure silica, and will readily enter into fusion when heated with a new portion of alkali.

Let us suppose the muriatic acid solution accomplished, the next step in the process is to evaporate this solution upon a sand-bath. Place the Wedgewood dish upon a sand-bath, and expose it to a heat sufficient to cause it to evaporate; but care must be taken not to raise the heat so high as to cause the liquid to boil, for in such a case a portion of it would be driven out of the dish and lost. When the liquid is considerably concentrated by evaporation, it loses its liquid form, and assumes that of a jelly, at least if it contains any considerable proportion of silica. As soon as this change has taken place we must stir it with a platinum spatula, and continue the agitation till the liquid is evaporated nearly to dryness. If this be neglected it is apt to sputter up, and part of it to be driven out of the vessel. Besides, the portion next the bottom is apt to be overheated, and some of the earthy salts might run some hazard of being decomposed. The evaporation need not be carried farther than the gelatinizing of the silica, if our sole object be merely to obtain the whole of that substance. For when silica is reduced to the state of a stiff jelly, it is no longer solnble in water.

Upon the gelatinous mass thus obtained distilled water is to be poured, the Wedgewood dish is to be put again upon the sand-bath, and the whole stirred about occasionally with the spatula, till the water has become almost boiling hot. The whole is now to be poured upon a filter. The silica having been rendered insoluble by the evaporation of the muriatic acid liquid to dryness, will remain upon the filter; but all the other constituents of the mineral, being in the state of muriates, will be dissolved in the water, and in that state will pass through the filter. Distilled water must now be poured upon the filter to wash the silica clean, and we must continue to do so till it passes through quite tasteless, and incapable of rendering a solution of common salt milky. The filter is now to be dried, and then accurately weighed. We then pour the silica into a platinum crucible, the weight of which has been previously noted. Wipe the filter quite clean with a cloth, and weigh it again. The difference of weight gives the quantity of silica collected on the filter. Let this weight be a. By weighing the platinum crucible containing the silica, we find the quantity of it which we have collected in that vessel. Let it be b. Expose the platinum crucible for half an hour to a red heat, and weigh it again as soon as it has become cold. The weight of the silica will be diminished; because it will, by the heat, be deprived of the whole water with which it was impregnated when weighed upon the filter. Let its new weight be c. Let the weight of the whole silica, supposing it had been exposed to a red heat, be x. We have

$b:c::a:x$ and $x=\frac{ac}{b}$.

Having thus obtained the silica in a separate state, the next step of the process is to separate and weigh the alumina. For this purpose we must pour carbonate of soda into the aqueous solution which has passed through the filter, till we throw down the whole of the constituents of the mineral that were united to the muriatic acid. This precipitate is to be edulcorated, and, while still moist, a quantity of caustic potash ley is to be poured over it, and the whole boiled for half an hour in a glass flask. The alumina, if any be present, will be dissolved in the ley, while the other substances will remain undissolved. Allow them to fall to the bottom. Decant off the potash ley; wash the residual powder clean with water, and add the liquid to the potash ley. Pour a solution of sal ammoniac into the potash till the liquid acquires a pretty strong smell of ammonia. The alumina will precipitate in white flocks. Continue to add sal ammoniac as long as any precipitate appears. The alumina thus separated must be washed, dried, and exposed to a red heat, and weighed.

Potash ley is capable of dissolving not merely alumina, but glucina also. The white powder thus precipitated by sal ammoniac, may therefore be glucina as well as alumina. To determine this point, we must dissolve it in sulphuric acid by the assistance of heat. If any portion remain undissolved, it must be considered as silica, and be added to the quantity of that substance found previously. Into the sulphuric acid solution we must pour a quantity of sulphate or muriate of potash, previously dissolved in water, and set the liquid aside for a few days. If the earth was alumina, we shall find a number of crystals of alum deposited at the bottom of the vessel. If it was glucina, no such deposite will have taken place. When all the crystals of alum that can be obtained have been deposited, we must wipe them dry and weigh them. The alumina which they contain, is equivalent to $\frac{10.86}{100}$ or 0.1086 of the weight of the crystals. If this weight be equal to the whole of the earth originally dissolved

in the sulphuric acid, we may conclude that the whole of that earth was alumina. But if there be a deficiency, the probability is that some glucina was also present. This will be found in the sulphuric acid solution, from which it may be precipitated by an alkaline carbonate. We may be certain that this precipitate is glucina, if we find it soluble in liquid carbonate of ammonia; if it forms sweet-tasted salts with acids; and if it be precipitated white from acids by prussiate of potash, and yellow by infusion of nutgalls.

If yttria be suspected in the matter which remained undissolved after the action of the potash ley, we may digest it in carbonate of ammonia, which will dissolve that earth, but leaves all the other ingredients untouched. And the yttria may be obtained pure, and weighed, by evaporating the carbonate of ammonia to dryness, and exposing the residue to a red heat.

The residue of the mineral thus deprived of the silica, alumina, glucina, and yttria, may still consist of lime, magnesia, oxide of iron, oxide of manganese, and in some rare cases of oxide of chromium and oxide of nickel. It is always proper to determine, by means of tests, which of these bodies are present and which absent; because the mode of the analysis must vary with the number and nature of the ingredients. If, for example, nothing were present but lime and oxide of iron, we should dissolve the whole in muriatic acid, precipitate the iron by means of ammonia, and the lime by means of oxalate of ammonia. If the residue consisted of lime, magnesia. and oxide of iron, we should dissolve it in dilute sulphuric acid, evaporate the solution to dryness at as low a heat as possible; water, mixed with a little alcohol, would dissolve the sulphate of magnesia and iron, but would leave the sulphate of lime. This last sulphate, being heated to redness and weighed, would give us the lime contained in the mineral, which will amount to $\frac{3.625}{8.625}$ or 0.42 of the sulphates. The iron may be precipitated from the liquid solution by means of benzoate of ammonia. The precipitate being washed, dried, exposed to a red heat, and weighed, will be red oxide of iron. Nine-tenths of its weight are equivalent to the black oxide of iron which existed in the mineral. The magnesia may now be precipitated by potash and weighed.

If besides these three ingredients oxide of manganese be likewise present, the very same method of proceeding will answer; only, after having separated the iron by means of benzoate of ammonia, we must pour a little hydrosulphuret of potash or ammonia into the liquid which still contains the magnesia and manganese. By this addition the manganese will be precipitated. If it be heated to redness for some time in an open vessel, its weight will indicate peroxide of manganese. To convert it into protoxide of manganese we must multiply the weight of peroxide by $\frac{9}{11}$ or 0.818.

The chromium, when present, is indicated by protonitrate of mercury, forming a red precipitate. When this metal is suspected in the mineral subjected to analysis, from the peculiar green or red colour which it has, we must employ nitric acid instead of muriatic to form the original solution. After the silica is separated, and the liquid deprived of its excess of acid by the requisite evaporation, we may precipitate the chromium by means of protonitrate of mercury. The precipitate being dried, exposed to a red heat, and weighed, will give the quantity of protoxide of chromium. If the chromium was present in the state of chromic acid, to obtain its weight, we must multiply the weight of the green oxide by 1.3.

Nickel has hitherto been found in one stony mineral only; the chrysoprase, which consists chiefly of silica, and has an apple-green colour. In this mineral it is associated with iron and lime. After the separation of the silica and alumina, the iron may be precipitated by ammonia, and when it is separated, we may throw down the nickel by hydrosulphuret of potash. Nothing will remain but the lime, which may be thrown down by an alkaline carbonate or by oxalate of ammonia.

After having thus obtained all the constituents of the mineral in a separate state, and determined the weight of each, the next step is to add all these weights together. If they amount to the weight of the portion of mineral analysed, we have reason to conclude that the analysis has been rightly performed. But if there be a deficiency, we have either committed an error, or the mineral contains some ingredient which we have overlooked.

As water occurs very frequently in minerals, we must in the first place endeavour to discover whether the deficiency be not owing to a portion of that substance which we have not reckoned. For this purpose we must take a determinate weight of the mineral (fifty grains for example), and expose it for an hour to a strong red heat in a platinum crucible. The heat will drive off the water, if any be present, and the deficiency of weight, after the mineral has been allowed to cool, will indicate the quantity of water which has been driven off.

If the mineral contain no water, or if the quantity which it contains be insufficient to make up the deficiency between the original weight of the stone, and the weight of the constituents which we have obtained, it may probably contain an alkali. For three different alkalies have been found in stones; namely, potash, soda, and lithina. To detect this alkaline ingredient we must make a second analysis of the mineral, but we must conduct it in a different way. Fifty grains of the stone, reduced to a fine powder, must be mixed with four times its weight of nitrate of barytes, or three times its weight of carbonate of barytes. This mixture must be exposed for two hours to a strong red heat in a platinum crucible. If nitrate of barytes be employed, it will enter into fusion at a comparatively low heat. Of course, if the mixture were exposed suddenly to a strong red heat, it would swell greatly, and a portion of it would probably be driven out of the crucible and lost. To prevent this we must raise the heat gra-

dually, and not bring it to the utmost degree of intensity till the nitrate of barytes has had time to lose most of its acid.

The fused mass is to be taken from the fire, allowed to cool, softened with water, and dissolved in muriatic acid, precisely in the way described at the commencement of this section. Into the muriatic acid solution a quantity of sulphuric acid is to be poured, capable of decomposing all the muriates and converting them into sulphates. The liquid becomes immediately milky in consequence of the precipitation of the sulphate of barytes. Separate this precipitate by the filter. Then pour an excess of carbonate of ammonia into the liquid, and boil the whole for some minutes. All the earths and metallic oxides will be precipitated, and nothing will remain in the solution but the sulphate of ammonia, and the sulphate of the alkali contained in the mineral, if any such existed in it. Evaporate the liquid to dryness, and expose the dry mass to a red heat in a platinum crucible. The sulphate of ammonia will be sublimed, and nothing will remain but the alkaline sulphate derived from the mineral. Weigh this sulphate, then dissolve it in water, and crystallize the salt. It will be easy, from the shape of the crystals, and the properties of the salt, to determine whether it be sulphate of potash, sulphate of soda, or sulphate of lithina. The composition of all these sulphates being known, we may easily deduce from the weight of the sulphate previously ascertained, how much potash, soda, or lithina, our mineral contained.

If no alkali can be detected in the mineral, it may contain *fluoric acid*, which constitutes an ingredient of the topaz, and of some other analogous minerals. To ascertain whether any of this acid be present, mix a portion of the mineral reduced to fine powder with sulphuric acid, and expose the mixture to heat in a glass vessel. If the glass be corroded, and if the vessel acquires a smell similar to that of muriatic acid, we may conclude that fluoric acid is present. To determine its quantity we must make a new analysis of the mineral. Fifty grains of it are to be fused with an alkali softened with water, dissolved in muriatic acid, and the silica separated by the method described at the beginning of this section. The remaining liquid is precipitated by carbonate of potash, and being filtered, and exactly neutralized, is precipitated by means of lime water. The precipitate is *fluor spar*. It must be exposed to a red heat. 26.5 *per cent.* of its weight indicates the fluoric acid, if we consider fluor spar as a fluate of lime. But if we consider fluor spar to be a compound of fluorine and calcium, according to the hypothesis of Ampere and Davy, in that case the fluorine will amount to 46.69 *per cent.* of the fluor spar obtained.

II.—*Carbonates.*

As the carbonic acid cannot be conveniently collected and weighed, we are under the necessity of adopting a different method for the analysis of the carbonates. Provide a small crystal phial with two mouths, as in fig. 21. To one of those mouths let a crystal stopper be fitted. The other must remain open. Pour into this phial a quantity of concentrated nitric acid, recently heated to deprive it of the nitrous gas which the smoking acid of the shops always contains. Put into the mouth of the phial a plug of cotton wool. Balance this phial accurately upon the scales of a good beam. Suppose the carbonate to be subjected to analysis to be calcareous spar or common limestone. Break the mineral into small pieces, of such a size that they can conveniently pass through the mouth of the phial. But let there be no powder. Into the same scale that contains the phial with the nitric acid, put fifty grains of these pieces, and counterpoise them exactly by fifty grains weight put into the opposite scale.

The nitric acid must have been poured into the phial through the mouth furnished with a glass stopper. As soon as it is poured in, the mouth must be wiped with a piece of paper, and the stopper put in its place. Remove the cotton plug, and with a pair of forceps lift up the pieces of calcareous spar, and put them one after another into the phial through the open mouth. Then replace the cotton plug. The pieces will immediately begin to dissolve with effervescence, owing to the escape of the carbonic acid gas, and in proportion to its escape the weight will diminish, and the opposite scale will preponderate. When the solution is completed, or when the effervescence is at an end, remove the phial from the balance; place it upon a table; take out the glass stopper and the cotton plug, then introduce through one of the mouths of the phial a small glass tube, and plunge it nearly, but not quite, so low as the surface of the nitric acid. Apply the mouth to the other end of the tube, and blow air gently through it for about a minute. Then draw in air through it into the mouth for about another minute. This will remove the carbonic acid gas which is usually floating in the empty part of the phial, and materially affects the weight. Put the glass stopper and the cotton plug again in their places. Put the phial on the same scale of the balance where it was before, and add weights till the equilibrium is restored. These weights are equivalent to the weight of the carbonic acid which had made its escape during the solution of the mineral in the nitric acid.

By the same method may the quantity of carbonic acid present in carbonate of strontian, carbonate of barytes, carbonate of magnesia, carbonate of iron, magnesian limestone, and, indeed, in all the carbonates, be ascertained. When carbonate of barytes is analysed in this way, we must dilute the nitric acid with water, otherwise the solution does not succeed. This renders the result not quite so accurate as it would otherwise be; for when the nitric acid is very weak, it is capable of retaining a portion of the carbonic acid in solution. We may, indeed, determine the bulk of the quantity thus held in solution, by putting the liquid into a small flask, or retort, furnished with a bent tube, passing into a mercurial trough. By carefully heating the liquid, we can drive off the carbonic acid gas, and measure its bulk in a glass jar standing inverted over the mercury. But such an experiment must be made with great caution, lest we drive over nitric acid, which would act upon the mercury, and produce nitrous gas, the evolution of which would disturb all our estimates.

The weight of carbonic acid in the carbonates being determined, we can ascertain that of the earthy bodies dissolved in the nitric acid, by the rules already laid down in a preceding part of this article. If there be any portion which refuses to dissolve in the nitric acid, we must carefully wash it, and dry it, and then heat it with thrice its weight of carbonate of soda. The fused mass may be analysed precisely in the way described at the beginning of this section.

One hundred parts of the earthy carbonates contain respectively, when quite pure, the following proportions of carbonic acid :

Carbonate of magnesia,	52.38	carbonic acid.
Lime,	43.14	
Strontian,	29.73	
Barytes,	22.00	

Knowing these proportions, we may easily deduce from the weight of carbonic acid, obtained from any native carbonate subjected to analysis, the degree of its purity with very little trouble.

We might lay down here rules for analysing the other earthy salts, as sulphates, phosphates, tungstates, &c. which occur ready formed in the earth. But such details would swell this article to too great a length. We must refer to the observations which we have already made on the analysis of the salts. The young analyst, who wishes to become expert in these analyses, cannot do better than procure a copy of Klaproth's *Beitrage, or Analytical Essays*, in six octavo volumes. The two first of them have been translated into English ; but the last four still remain in the original German. In these volumes he will find examples of the analysis of almost every earthy salt, and, by imitating the methods there laid down, he will soon become an expert analyst, and will be able even to improve upon Klaproth's processes, by applying to them various discoveries which have been made since the original publication of these experiments.

Chap. VI.—Of Ores.

The term *ore* is applied to all those mineral bodies from which metals are extracted to answer the purposes of civilized society. The term has been extended, by mineralogists, to all those minerals which contain a notable proportion of metal, whether that metal be considered of such value as to be extracted from the ore or not. Thus, *wolfram* is considered as an ore, though the *tungsten*, which constitutes its principal constituent, has not hitherto been applied to any useful purpose, and, of course, though wolfram is never collected for the purpose of extracting from it the tungsten for the uses of civilized society.

The ores are so numerous, and so complex in their nature, that a general formula of analysis cannot be applied to them all. Many of them, indeed, cannot be looked upon in any other light than as mere mechanical mixtures ; an accurate analysis of which cannot be of any utility for the purposes of science, because no two portions would yield exactly the same result ; though it may frequently be of consequence to miners and metallurgists to know the constituents of even such mechanical mixtures, when they happen to occur abundantly in any peculiar place ; because such knowledge will facilitate the invention of processes for extracting the useful metals out of the mixture.

To enter upon a minute detail of the various methods employed for the analysis of the ores, would be to extend this article to a disproportionate length. All we can do is, to make a few general observations on the mode of analysing the most important ores, which are likely to come in the way of the young chemist.

Metals occur in the earth in five different states, 1. As metals, either alone, or more commonly united with each other, constituting *alloys*. 2. United to sulphur, constituting *sulphurets*. 3. United to oxygen, constituting *oxides*. 4. United to chlorine, constituting *chlorides*. 5. In the state of oxides united to acids, and constituting *salts*. As the mode of analysis differs materially according to these states, it will be proper to consider each of them separately.

I.—*Alloys*.

Gold, platinum, palladium, iridium, and tellurium, have hitherto been found only in the state of alloys.

Silver, copper, bismuth, and arsenic, occur very frequently in that state ; and mercury, iron, cobalt, nickel, and antimony, occur in it occasionally.

Gold occurs either pure, or alloyed with silver or copper, or both. The mode of analysing such alloys has been given in a preceding chapter.

No accurate and simple mode of analysing the alloys of platinum, palladium, and iridium, has yet been found out. For the methods at present known, the reader is referred to Wollaston, *Phil. Trans.* 1804 and 1805 ; Tennant, *Phil. Trans.* 1804 ; and Vauquelin, *Ann. de Chimie*, 88.

Tellurium occurs alloyed with gold, iron, silver, and lead. If the alloy be treated with nitro-muriatic acid, all the metals will be dissolved, except the silver, which will remain in the state of a chloride, from which the quantity of it may be ascertained. Potash poured in excess into the liquid will precipitate the gold and the iron, but will keep the tellurium and the lead in solution. If the precipitate of oxides of gold and iron be moderately heated, the gold will be restored to the metallic state. Muriatic acid will then dissolve the iron, and leave the gold untouched. We may precipitate the iron by means of ammonia, and determine its quantity. The lead may be precipitated from the potash solution by means of sulphate of soda, and the tellurium by saturating the potash with muriatic acid.

Silver, when in the metallic state, occurs either pure, or alloyed with gold, antimony, lead, arsenic, bismuth, or iron. It may be dissolved in nitric acid, —the gold will remain in the metallic state. Water will precipitate the antimony and bismuth, sulphate of soda the lead, muriate of lime the arsenic, and ammonia the iron.

Native copper has scarcely been subjected to

analysis. It may be dissolved in nitric acid. Sulphate of soda will precipitate the lead, if it contain any, and common salt the silver.

The other native metals have not hitherto been subjected to analysis. We may proceed according to the rules laid down in a preceding chapter, when treating of the metals.

II.—*Sulphurets.*

The following metals occur in the state of sulphuret: Mercury, silver, copper, iron, cobalt, molybdenum, tin, zinc, bismuth, lead, antimony, and arsenic.

In these sulphurets the proportion of sulphur and of metal is always such, that if the sulphur were converted into sulphuric acid, and the metal into an oxide, the acid and oxide would be capable of uniting together, and of forming a neutral sulphate. The method of analysis is, to treat the sulphuret with nitric acid, till the whole sulphur is acidified. In some cases, as mercury, silver, lead, we shall, by this process, form an insoluble sulphate. If this sulphate be washed, dried, and weighed, it will enable us to determine the proportion of the constituents of the sulphuret before the experiment. Thus, 100 parts of sulphuret of lead, when converted into sulphate of lead, will weigh $126\frac{2}{3}$; of this $\frac{4}{19}$ths, or 0.21, consist of oxygen added by the action of the nitric acid. The remaining $\frac{15}{19}$ths consist of sulphur and lead, in the proportion of 2 sulphur and 13 lead, or, in other words, sulphuret of lead is composed of

Lead -	$86\frac{2}{3}$
Sulphur	$13\frac{1}{3}$
	100

When sulphuret of bismuth or antimony have been converted into sulphates, if we pour water in sufficient quantity upon the mass, the acid is dissolved in the liquid, while the oxides of the metals remain in the state of a white powder. This powder being washed, dried, and heated to redness, will give the weight of the antimony or the bismuth respectively, by applying the rules laid down in a preceding chapter. The sulphuric acid is to be precipitated in the state of sulphate of barytes, and the weight of the acid is to be estimated by the rules previously given. Knowing the weight of sulphuric acid, it is easy to deduce that of the sulphur; for $\frac{2}{5}$ths of the weight of that acid are sulphur, and the remaining $\frac{3}{5}$ths oxygen.

III.—*Oxides.*

The following metals are found in the earth in the state of oxides: Silver, copper, iron, manganese, uranium, cerium, tantalum, cobalt, nickel, tin, titanium, zinc, bismuth, lead, antimony, and arsenic.

These oxides occur sometimes in a separate state, but more frequently mixed together, or united either mechanically or chemically to different earths, particularly alumina. To be able to analyse them, we must make ourselves well acquainted with the properties of the metals, as detailed in a preceding chapter, and with the various oxides which these metals are capable of forming; their solubility or insolubility in various acids; and the action of the alkalies and various saline solutions upon these liquids. Upon a knowledge of these properties depends the power of being able, successfully, to separate them from each other.

As an example of the mode of analysing a mixture of metallic oxides, we may take red silver ore, which has the aspect of a chemical compound of silver and antimony, both in the state of oxides, and containing likewise a quantity of sulphur. When digested in diluted nitric acid, about 58 *per cent.* of it is dissolved. When the residual parts are digested in muriatic acid, a part dissolves, and a portion remains undissolved. This last portion burns all away, with a blue flame, when heated, and consequently is sulphur. When the muriatic acid solution is diluted with water, a white powder falls, which is hydrate of antimony. The nitric acid solution, being mixed with common salt, the silver is precipitated in the state of chloride. These are the only constituents of the ore. We have given the analysis of red silver ore, because we are far from thinking that it has hitherto been analysed in a perfectly satisfactory manner. The present advanced state of the science would enable the chemist to go farther than Klaproth or Vauquelin were able to do at the time that their analyses were published, and to determine what portion of the respective metals are in the state of oxides, and what portions are combined with sulphur in the metallic state.

IV.—*Chlorides.*

The only metals hitherto found in the earth, in the state of chlorides, are mercury, silver, and lead; mercury, in the state long well known by the name of Calomel, which is a protochloride; and the silver and lead, in what was formerly called Horn-silver and Horn-lead. These chlorides are easily reduced to the metallic state, by means of hydrogen, or when treated with substances containing hydrogen. Knowing the weight of metal which they contain, it is easy to deduce the proportion of chlorine which makes up the remainder of their weight. The proportion of chlorine and metal which exists in each of these chlorides is as follows:

Chlorine.

4.5 + 25 mercury = 29.5 chloride of mercury.
4.5 + 13.75 silver = 18.25 chloride of silver.
4.5 + 13 lead = 17.5 chloride of lead.

V.—*Salts.*

The following metals are found in the earth in the state of salts: Silver, copper, iron, manganese, cerium, cobalt, titanium, zinc, and lead.

Silver occurs in the state of carbonate.

Copper in the state of carbonate, silicate, carbosilicate, arseniate, muriate, phosphate, and sulphate.

Iron in the state of carbonate, phosphate, arseniate, chromate, silicate, tungstate, and sulphate.

Manganese in the state of phosphate and silicate.

Cerium in the state of silicate and fluate.

Cobalt in the state of arseniate and sulphate.

Titanium in the state of silicate.

Zinc in the state of silicate, carbonate, and sulphate.

Lead in the state of carbonate, murio-carbonate, phosphate, arsenio-phosphate, chromate, sulphate, molybdate, arseniate.

For the rules by which the analysis of these salts is to be conducted, we must refer to our observations on the mode of analysing salts, in a preceding chapter of this article.

Chap. VII.—Of Vegetable Substances.

The species of plants are so numerous, so different from each other, so beautiful, and so useful, that they are likely to present themselves to the chemist more frequently than any other class of bodies whatever. Unfortunately, our methods for analysing vegetable substances are much more imperfect than those which we employ in our experiments upon mineral bodies. Vegetable substances are so numerous, so easily altered or even destroyed, our processes for separating them from each other are so imperfect, that no two analyses of the same body could be expected to correspond exactly with each other. All that we can do, therefore, is to point out the processes which are usually followed, and the substances which these processes are capable of separating from each other. The greater number of vegetable substances either exude spontaneously from plants, or they are obtained by processes which sacrifice all the other constituents to one peculiar and important substance; which it is the object of the process to procure. Thus gums, resins, birdlime, caoutchouc, the gum-resins, and balsams, exude spontaneously. Sugar, indigo, starch, oils, both fixed and volatile; camphor, wax, &c. are obtained by simple and well known processes from the peculiar plants which yield them, while every other part of the plant is sacrificed to these favourite educts.

In general, it is not possible to make the weight of the substances extracted from any part of a plant to correspond with the weight of the part from which they were extracted. We have no mode of bringing vegetable bodies to the same accurate state of dryness. If we expose them to a red heat, they all undergo decomposition, and are converted into water, carbonic acid, carbureted hydrogen, oil, acetic acid, and other similar substances, quite different in their nature from the body which we exposed to heat. It is very seldom that we can venture to expose a vegetable substance to a temperature higher than that of boiling water. Some of them, as saccharine matter of malt, are not capable of bearing even that temperature without alteration. Nor can there be any reason to doubt that the leaves, the petals, and even the bark of many plants will be altered, if we expose them to such a temperature.

We are under the necessity, in consequence of this easy alterability of vegetable bodies, to subject them to analysis precisely in the state that we find them; though this precludes the possibility of making the weight of the educts tally with that of the substance subjected to analysis. These educts are dried at the temperature of boiling water when they are capable of bearing that temperature, and when this is not the case, we are obliged to weigh them as we get them.

There is another method of drying vegetable bodies, which has been put in practice of late years, and which is undoubtedly better than exposing them to heat. It consists in putting them in the exhausted receiver of an air-pump, while a flat glass dish, containing a quantity of concentrated sulphuric acid, covers the bottom of the receiver. By this contrivance, they are more thoroughly dried than they would be by the heat of boiling water, while they run no risk of being decomposed by heat. But even this method cannot be applied to the leaves, petals, and other soft and delicate parts of plants, without producing considerable alterations. The leaves and petals change their colour, and the more volatile parts of these organs make their escape, and are absorbed by the sulphuric acid. Upon the whole, therefore, it is better to take the parts of plants to be subjected to analysis just as we find them. We may form an estimate of the quantity of water which they contain, by heating another portion, or exposing it under an exhausted receiver along with sulphuric acid.

Let us suppose then a vegetable substance, as a wood, bark, or the leaves of some particular tree, to be subjected to analysis. In order to give a precise example of the methods followed, we shall take the root of the *Glycyrhiza glabra* or *liquorice*, a plant which is cultivated in the south of Europe for the sake of the saccharine extract which is obtained from it, and which is well known by the name of liquorice sugar. This root has been frequently subjected to analysis by chemists, but the most instructive analysis of it which has yet appeared is by Robiquet, in the *Annales de Chimie*, Vol. LXXII. p. 143.

A quantity of fresh liquorice root, washed quite clean, and divided as much as possible, was put into cold distilled water, and allowed to remain for twelve hours, when the liquid was filtered. It had assumed a reddish brown colour, and of course had dissolved a portion of the root.

This liquid being left at rest for some time, allowed a white powder to precipitate, which possessed the properties of *starch*.

The liquid thus freed from starch had a sweet taste accompanied with a certain acridity. When examined by reactives, it exhibited the following properties:

1. It reddened paper stained with litmus, and of course contained an acid.

2. Infusion of nut-galls and alcohol occasioned a slight precipitate. Hence it probably contained vegetable *albumen*.

3. A solution of glue in water occasioned no change in it. Therefore, it contained no sensible portion of tannin.

4. The acids occasioned a copious coagulation in it.

5. Potash occasioned no other change but altering the shade of colours. Hence it contained no notable proportion of earthy salt.

6. Lime water occasioned a copious precipitate. Hence it might contain phosphoric acid.

7. Oxalate of ammonia occasioned a gritty white precipitate. This might indicate the presence of lime. But the presence of this earth is rendered unlikely, by the action of potash on the liquid.

8. Acetate of lead formed a very copious magma. This might be owing to the presence of malic or phosphoric acid, or several other vegetable substances with which the oxide of lead unites.

9. The salts of iron and the muriate of barytes likewise occasioned similar precipitates. This seems to indicate the presence of phosphoric acid in the liquid.

The coagulation produced by the acids indicating the presence of some peculiar principle in the liquid, the next object was to separate this principle, and examine its properties. For this purpose, a quantity of the liquid was heated in a glass vessel, and boiled for a few minutes, to separate the vegetable albumen, the presence of which had been indicated by the action of infusion of nut-galls. For vegetable albumen coagulates and precipitates in flocks, when the liquid holding it in solution is heated. The flocks which fell by this process being separated by the filter, the liquid was allowed to cool, and, when quite cold, a little distilled vinegar was mixed with it. Some flocks appeared at first, which speedily increased in quantity so much, that they exhibited the appearance of a transparent gelatinous magma, which, when separated by the filter, and washed with cold water, constituted the substance to which liquorice owes its sweet taste. This substance possesses peculiar characters, and approaches sarcocoll in its properties.

Its colour is yellow, its taste precisely similar to that of liquorice. Its bulk diminishes very much in drying. The dried mass is scarcely soluble in cold water, but it dissolves readily in hot water; and if the solution be concentrated, it assumes, on cooling, the state of a transparent solid jelly. Cold alcohol dissolves it readily, and assumes a dark yellow colour, a syrupy consistence, and a sweet taste. When dissolved in water, and mixed with yeast, it does not ferment; neither does it yield any oxalic or malic acid when treated with nitric acid; but is converted chiefly into a yellow opaque mass, having but little taste, and similar in appearance to a resin.

The liquid, which had been deprived of the saccharine matter by means of distilled vinegar, still retained its colour. Acetate of lead formed in it a copious precipitate, and left the liquid colourless. A portion of the leaden precipitate being exposed to heat before the blow-pipe blackened, and then fused into an opaque bead, which, on cooling, assumed the shape of an irregular polyhedron. This indicates that it consisted chiefly of phosphate of lead. The whole of the precipitate being diffused through water, the lead was thrown down by means of a current of sulphureted hydrogen gas. There remained in solution in the water phosphoric acid, malic acid, and the substance which gave the infusion of liquorice its yellowish brown colour.

The original liquid, which had been freed from its colour by means of acetate of lead, was treated with sulphureted hydrogen gas, to throw down any excess of lead which might still remain in it. It was then filtered, concentrated by evaporation, and set aside for some days. Fine transparent crystals were deposited, having the form of rectangular octahedrons. Their nature was not particularly examined, but they probably consisted of *asparagin*.

Such are the substances which may be extracted from liquorice root by means of water. The next step in the analysis of a vegetable substance, is to try the effect of *alcohol* upon it.

A quantity of liquorice root was macerated in successive portions of alcohol, till it ceased to communicate any colour to that liquid. When the alcoholic solution was evaporated, a thick brown viscid oil separated from it. This oil had at first a sweetish taste, but it soon left a very acrid impression, which was felt most strongly in the throat.

Liquorice root, having been thus treated by water and alcohol, was exposed to the action of very dilute nitric acid. But, after macerating in that liquid for a fortnight, nothing was dissolved but a little phosphate of lime.

The residual matter now consisted chiefly of woody fibre. To determine what saline bodies it contained, it was burnt. It left a bulky ash, which contained a good deal of carbonate of lime and phosphate of lime.

As a second example of vegetable analysis, we shall give that of *rice*, or the seeds of the *Orysa sativa*, as performed by Braconnot (*Ann. de Chim. et Phys*. 4. 370).

One hundred parts of Carolina rice being dried, were found to lose 5 *per cent*. of their weight. Being put into water, of the temperature of 122°, they absorbed that liquid with avidity, and opened transversely in several parts. When so soft that they could easily be squeezed into a fine powder between the fingers, they were thoroughly pounded in a glass mortar, along with a sufficient quantity of the water in which they had been macerated. A milky liquid was thus obtained, which was thrown upon a filter. The greatest part of the substance of the rice remained upon the filter. This portion, being well washed and dried, weighed 93.67. The watery liquid which passed through the filter we shall call A.

The 93.67 parts, which remained upon the filter, being diffused through water, passed entirely through a silk scirse. This milky liquor contained two distinct substances: the first, which was very white, and by far the most abundant, remained long in suspension; but the second, which was much less white, was of a greater specific gravity, and, of course, fell more speedily to the bottom. Advantage was taken of this difference, to separate these two substances from each other. The whitest of the two possessed all the properties of *starch*. It had a fine white colour, was light, and, when pressed, a peculiar noise could be perceived. When triturated in a mortar with a little iodine, it assumed a deep blue colour. It formed a kind of jelly when boiled in water. When one part of it was boiled in 4000 parts of water, the liquid, which was limpid, was precipitated by lime water, barytes water, and the infusion of nut-galls. The other substance was the parenchyma of the rice, but not quite free from starch.

The liquid A, having the property of reddening vegetable blues, was put into a retort, and a portion of it distilled over. This portion was mixed with a little barytes water, and then evaporated to dryness. A small portion of residue remained, which, being placed in contact with diluted sulphuric acid, gave out the odour of acetic acid. Hence it is evident, that the liquid A owed the property of reddening vegetable blues to the presence of a little acetic acid.

During the distillation of the liquid A it became opaque, and at last let fall a small quantity of white matter, which had not the aspect of albumen. The whole of the liquid, including the precipitate, was poured into a small porcelain capsule, and evaporated to dryness. The residue weighed 1.28; it had a pale yellow colour, and attracted humidity from the atmosphere. It was mixed with a little water to give it the consistence of a syrup, then alcohol was poured into it. A copious precipitate fell, which, being collected and dried, weighed 0.99. This matter dissolved in cold water, with the exception of 0.13 of white flocks which remained undissolved, and possessed the properties of albumen. The dissolved portion approached more nearly to the properties of torrefied starch than to those of gum.

The alcohol held in solution 0.29 of a syrupy matter, having the taste of sugar, the smell of honey, incapable of crystallizing and attracting humidity from the atmosphere.

The gummy matter contained mixed with it phosphate of lime, phosphate of potash, and a little lime combined with a vegetable acid.

The parenchyma was completely freed from starch, by boiling it for half an hour in water acidulated with sulphuric acid. The weight of the starch was found to be 85.07; that of the parenchyma 4.8.

When macerated rice is digested in alcohol for 24 hours, if the alcohol be separated by the filter and evaporated, it leaves behind a small quantity of a fat oil, almost colourless, having a rancid taste and smell, the consistence of thick olive oil, and easily soluble in alcohol and alkalies.

These examples are sufficient to give the reader some notion of the method of proceeding, when vegetable bodies are to be analysed. The art has not yet reached such perfection as to enable us to lay down general formulas, which will serve for every case. Almost always we begin by treating the vegetable substance with water. When every thing soluble in water has been removed, we treat it with alcohol. After the action of these two solvents has been exhausted, we sometimes employ sulphuric ether, sometimes acetic acid, sometimes dilute nitric acid, and sometimes potash ley, according to the nature of those substances which we suppose to exist in it. The young chemist who intends to devote himself to vegetable analysis, ought, in the first place, to make himself familiarly acquainted with the properties of all the vegetable principles, with their solvents and their precipitants, by a set of experiments, which must be repeated with all the requisite accuracy, till the facts are engraved upon his memory. He may then repeat some of the most elaborate vegetable analyses that have hitherto been performed. For a knowledge of these analyses we refer him to the 4th volume of Dr Thomson's *System of Chemistry*, p. 207 (5th edition), where he will find a pretty complete collection of them, with exact references to the original books, where these analyses were published.

But the vegetable principles themselves are all compounds of various proportions of oxygen, carbon, hydrogen, and azote, and, in order to form correct notions respecting their nature and constitution, it is requisite to be acquainted with the exact proportions in which their constituents exist in each of them. It is only since the introduction of the Atomic Theory into chemistry, that such investigations can be attended with much advantage. But an accurate knowledge of the composition of vegetable bodies would undoubtedly throw considerable light on the atomic theory, which is still in a very imperfect state. It would be requisite, however, to apply the atomic theory to vegetable analysis, with much greater caution than has been hitherto done. For when we find by analysis that any vegetable principle yields a certain number of atoms of hydrogen, carbon, and oxygen, we have no right to infer that these atoms were immediately united with each other. They might have been previously united into a certain number of binary or even ternary compounds, and these compounds, united together, may constitute the vegetable substance which we have subjected to analysis. Our object at present is merely to point out the method of determining the proportion of oxygen, carbon, and hydrogen, which exist in any vegetable principle, as sugar, gum, starch, &c.

The first successful attempt at such analysis was made by Gay-Lussac and Thenard in the second volume of their *Memoires Physico-Chimique*. They made up the vegetable substance to be analysed into balls, with a certain quantity of chlorate of potash; taking care to mix them as intimately as possible. These balls were burnt in a glass vessel by the application of the heat of a lamp. The carbon was converted into carbonic acid gas, the hydrogen into water. The quantity of carbonic acid and water yielded by a determinate weight of any vegetable principle being known, it was easy to determine the weight of carbon and hydrogen which it contained, and the deficit of weight was considered as oxygen. This method does not answer for those vegetable substances that contain azote as a constituent. For in such cases ammonia or nitric acid might be formed, which would prevent the possibility of deducing any consequence from the experiment.

The method of Gay-Lussac and Thenard was considerably modified by Berzelius, in his paper on the analysis of vegetable substances, published in the 4th volume of Thomson's *Annals of Philosophy*. He employed a mixture of chlorate of potash and the vegetable body, as the French chemists had done; but the combustion took place in a glass tube hermetically sealed to another glass tube, containing muriate of lime, and from this passed another tube into the mercurial trough. The water formed was condensed in the muriate of lime, and its weight

ascertained. The carbonic acid gas passed into a glass jar standing over mercury, and its bulk and purity were easily determined. This method had an obvious advantage over that of the French chemists, who had no means of collecting and estimating the water formed during the process. But it is obviously impossible by means of Berzelius's method, any more than by that of the French chemists, to determine the composition of those bodies which contain azote.

More lately, Gay-Lussac has suggested a new method of analysing vegetable substances; namely, heating them in a tube with peroxide of copper. This method we have frequently practised. It seems easier than either of the two preceding ones, and has the advantage of enabling us to determine the composition of bodies which contain azote. For if the action of the heat be properly regulated, the azote comes over in the state of gas, mixed with the carbonic acid gas, formed by the process, and the quantity of each of these gases is easily determined by analysis. The water is collected by means of a tube filled with dry muriate of lime. We shall, therefore, describe here the method of analysing vegetable bodies by means of peroxide of copper.

Procure a copper tube, bored from a solid copper rod about twelve inches long, and with a bore of about one-third of an inch in diameter. To the mouth of this tube a brass tube must be ground air-tight. This brass tube may be about four inches long, and bent as in figure 22. The end *a* of the tube being the one which is ground to the mouth of the copper tube. To the end *b* of the brass tube, a glass about six inches long is fitted, so as to be nearly air-tight. This glass tube is bent at the end, so that it can be introduced below the mouth of a glass jar, standing inverted upon the mercurial trough and full of mercury. The glass tube is filled with dry muriate of lime, in the state of powder. The upper and lower ends are filled with amianthus. Its weight must be carefully ascertained and written down. For greater security, let the glass tube be luted to the brass tube. Fill the brass tube with amianthus. Weigh out three grains of the vegetable substance to be analysed. It is best to take it in its natural state, without freeing it from the water which it may contain. This water must be ascertained by other experiments, and its quantity allowed for in the analysis. Mix these three grains with 120 grains of peroxide of copper, previously reduced to the state of a fine powder. The mixture must be as intimate as possible, that is to say, the vegetable substance must be equally diffused through the whole of the oxide of copper. Put the mixture into the copper tube. It will fill about five inches of it. Fill up the tube now completely to the mouth with peroxide of copper, and put a little amianthus over it, to prevent any of the oxide from falling out. Then fix the brass tube in the copper one. Put the copper tube upon a small iron chaffer or cradle, so that one-half of the tube is within the chaffer and the other half on the outside, and the whole apparatus must be so placed, that the extremity of the glass tube is below an inverted glass jar, standing over mercury, in the mercurial trough. That portion of the copper tube which is on the outside of the chaffer, is now to be covered with a coat of moist clay, about an inch in thickness. This covering will prevent the heat from passing nearly so rapidly along the copper tube; the consequence of which will be, that the brass tube will remain comparatively cool during the whole experiment. A few pieces of burning charcoal are now placed round the portion of the copper tube which is within the chaffer. The fire is made to commence at the end of the tube nearest the mercurial trough, and it proceeds gradually backwards to the bottom of the tube. Care should be taken to keep the fire low, and to let the combustion proceed slowly. The copper tube need hardly be heated red-hot; though, to be sure that the combustion has been complete, we are always in the habit, just before we terminate the process, to make the whole of the copper tube within the chaffer distinctly red-hot. If the vegetable substance analysed happens to contain azote, there seems to be a temperature somewhere about a red heat, at which nitric acid is formed. As such a product would destroy the accuracy of the experiment, it is material to keep the heat so low as to prevent the risk of any such formation.

As soon as the temperature rises sufficiently high, the vegetable substance is completely decomposed. The carbon which was contained in it combines with oxygen, contained in the oxide of copper, and is converted into carbonic acid. The hydrogen combines with oxygen, and is converted into water, while the azote makes its escape in the gaseous state. The carbonic acid and azotic gases will be collected in the graduated glass jar over the mercury. To ascertain the bulk of each, let up into the jar a quantity of potash ley, and let it stand in contact of the gases for twenty-four hours. The whole of the carbonic acid will be absorbed. The diminution of bulk will give the quantity of carbonic acid, while the residual bulk will give the quantity of azotic gas; making allowance for the alteration in the bulk occasioned by the column of mercury in the jar, and by any change of temperature that may have taken place during the continuance of the experiment. Indeed, it is always necessary to reduce the gases to the bulk which they would occupy at the temperature of 60°, and when the height of the barometer is 30 inches;—because the specific gravity of these gases, which enters as an indispensable element in our calculations, was estimated at that temperature. Knowing the bulk of these gases, it is easy to deduce their weight, and hence to know the quantity of carbon and azote which the three grains of the vegetable substance analysed contained. The increased weight of the muriate of lime will give us the water formed by the process, or separated from the vegetable substance by the heat. Subtracting from this weight the known proportion of water contained in the vegetable substance, determined by other experiments, the remainder will be the water formed by the union of the hydrogen in the vegetable substance with the oxygen of the oxide. One-ninth of the weight of this water is the hydrogen contained in the three grains of vegetable substance analysed. Thus we determine the weight of the azote, carbon, and hydrogen, which our vegetable

substance contains. Add all these weights together. If they amount to three grains, we may conclude that our substance contains no oxygen; but if the weight (as will almost always happen) be less than three grains, we must suppose that the substance contained a quantity of oxygen, the weight of which, when added to that of the other constituents, will make up the weight of three grains (the water which exists as a constituent of the body being supposed subtracted).

It may be worth while to give an example or two of this mode of analysis, that the reader may be able to form a correct idea of it.

0.333 part of acetic acid united to protoxide of lead, furnished, when burnt by means of chlorate of potash, 0.18 water, and 0.574 of carbonic acid. From this result it is inferred by Berzelius, that 100 of acetic acid are composed of

Hydrogen,	6.35
Carbon,	46.83
Oxygen,	46.82
	100.00

Four grains of uric acid being mixed with peroxide of copper, and analysed in the way above described by Dr Prout, yielded

Water, -	1.05 grain.
Carbonic acid gas,	11 cubic inches.
Azotic gas, -	5.5 ditto.

Hence he infers that it is composed of

Hydrogen,	0.11 or	2.857
Carbon,	1.37	34.286
Azote,	1.61	40.000
Oxygen,	0.91	22.857
	4.00	100.000

Five grains of crystallized triple prussiate of potash yielded to Dr Thomson, when treated in the same way,

Water,	1.55 grain.
Carbonic acid,	5.205 cubic inches.
Azotic gas,	2.420 ditto.

Now, the gaseous part of the acid in five grains of this salt (excluding the iron which it contains) weighs 1.54 grains. Hence it is concluded that this gaseous part is composed of

Carbon,	0.6579 or	42.51
Azote,	0.7175	46.37
Hydrogen,	0.1722	11.12

But the mere knowledge of the respective weights of the elements of which these bodies are composed, throws but little light on their constitution. We must know the number of atoms of each of the elements which exist in them. Now, the weight of an atom of each of these elementary bodies has been ascertained to be as follows:

Oxygen,	1.00
Azote,	1.75
Carbon,	0.75
Hydrogen,	0.125

The comparison of the weights with the weights of the elements found in one hundred parts of the vegetable body analysed, will give the relative proportion of atoms of each. Thus, in the case of acetic acid, the numbers

6.35
46.83
46.82

bear the same ratio to each other, as the numbers

0.125×3
0.75×4
1.00×3

That is to say, that acetic acid may be conceived a compound of 3 atoms hydrogen + 4 atoms carbon, + 3 atoms oxygen.

But before we can know whether these are the true number of atoms in acetic acid, we must know what the relative weight of an atom of acetic acid is. This is known when we ascertain the weight of acetic acid which is capable of saturating an atom of each of the bases. Now, according to the analysis of Berzelius, acetate of lime and acetate of lead are composed as follows:

Acetate of lime.

Acetic acid,	100	or 6.615
Lime,	54.8	3.625

Acetate of lead.

Acetic acid,	100	or 6.432
Oxide of lead,	217.662	14.

Now, as these salts are neutral, we have reason to conclude that they are composed each of an atom of acetic acid, united to an atom of base. An atom of lime weighs 3.625, and an atom of oxide of lead 14. We see from the first salt that an atom of acetic acid weighs 6.615, and from the second that it weighs 6.432. The second of these determinations is more likely to be correct than the first, because it is easier to free acetate of lead of its water than acetate of lime. Hence we may conclude, that the weight of an atom of acetic acid does not exceed 6.432. Let us now see what the weight of 3 atoms hydrogen, 4 atoms carbon, and 3 atoms oxygen will be.

$$\begin{aligned} &\text{3 atoms hydrogen} = 0.125 \times 3 = 0.375 \\ &\text{4 atoms carbon} = 0.75 \times 4 = 3.000 \\ &\text{3 atoms oxygen} = 1. \times 3 = 3.000 \\ &\hline \\ &\qquad\qquad 6.375 \end{aligned}$$

We perceive that they amount to 6.375. Now, as 6.375 is very near 6.432, but rather under it, we have a right to conclude that acetic acid consists of

3 atoms hydrogen.
4 atoms carbon.
3 atoms oxygen.

The small difference is either owing to errors in the

analysis of acetate of lead, or to the impossibility of freeing that salt entirely from water.

Chap. VIII.—Of Animal Substances.

The analysis of animal substances is conducted nearly on the same principles as that of vegetable substances. But greater progress has been made in it. This is partly owing to the comparatively small number of animal principles hitherto discovered, at least in the bodies of the larger animals, to which chemical analysis has been hitherto chiefly confined. But it is mainly owing to the great importance which medical men have attached to an accurate knowledge of the constituent parts of the human body. This has occasioned a more laborious examination, and has led to pretty precise methods of detecting the presence of the different animal bodies, and of determining the weight of each.

The animal substances of which the soft parts of the larger animals are composed, and which exist chiefly in the liquids of the body, may be reduced nearly to the four following:

Gelatin.
Albumen.
Fibrin.
Colouring matter of blood.

It will be requisite to give the characteristic properties of each of these bodies, and to show how their presence may be detected in such animal liquids as happen to contain them.

1. As far as we know at present, gelatin never exists as a constituent of any of the animal fluids. It is extracted from the skin and from the membranes by long boiling. They gradually dissolve in the water, and seem to be converted into gelatin.

Gelatin, when in a solid state, is the substance called in common language *glue*. When pure it is semitransparent and white. When put into cold water it swells very much, and assumes a gelatinous consistence, but does not dissolve. In hot water it dissolves; but when the liquid cools it becomes a solid jelly, provided the gelatin dissolved in it amount to $\frac{1}{100}$th of the weight of the water. One part of gelatin dissolved in 150 parts of hot water forms a liquid which does not gelatinize on cooling. This liquid is not precipitated by *corrosive sublimate;* but it is abundantly precipitated by infusion of *nut-galls.*

2. Albumen is the substance which gives the characteristic properties to the white of an egg and to the serum of blood. When either of these liquids is exposed to the temperature of 165°, it coagulates into a white or pearl coloured stiff mass. It is this coagulation by heat which characterizes albumen. If an acid, or alcohol, or sugar, or a salt, be dissolved in a liquid containing albumen, coagulation takes place. A liquid containing albumen is precipitated copiously by corrosive sublimate and acetate of lead. The infusion of nut-galls throws it down likewise, but is by no means so delicate a test of albumen as it is of gelatin. For example, it does not detect one part of albumen dissolved in 1000 parts of water.

3. Fibrin is so called because the fibres of the muscles are chiefly composed of it. Blood also contains it as an essential constituent. When a quantity of blood newly drawn from an animal is allowed to remain for some time at rest, a thick red clot gradually forms in it and subsides. If we take out this clot and wash it gently in water till that liquid ceases to become coloured by it, the portion which remains undissolved is fibrin.

Fibrin thus obtained is a white substance, at first soft and elastic; but it becomes hard when dried. It is insoluble in cold water; but when that liquid is long boiled upon it, it becomes milky. Infusion of nut-galls throws down flocks from this solution, which do not adhere together like the tannate of glue. The fixed alkaline leys dissolve fibrin when assisted by heat; so does acetic acid. Muriatic acid combines with it in two proportions. That which contains the least acid dissolves in water; but the other, containing a greater proportion, is insoluble in that liquid. Alcohol and ether gradually convert fibrin into a kind of fatty matter.

4. The water with which the clot of the blood has been washed (supposing it previously, by means of blotting paper, freed from the serum) contains in solution the colouring matter of the blood; and this matter may be obtained in a separate state by coagulating that liquid by exposure to heat. When the coagulum is dried at the temperature of 158° it becomes black, hard, difficultly pulverizable, and breaks with a vitreous fracture. The action of reagents on it in this state is nearly the same as upon fibrin.

By these properties may these different substances be recognised in the animal bodies that contain them. The albumen, fibrin, and colouring matter undergo certain changes in the fluids of secretion, to fit them for the purposes for which they are intended. In the bile they are converted into picromel, in the milk to curd, sugar of milk and cream. In the secretion of the nose to mucus. Urine contains a peculiar substance, called *urea*, seemingly formed in the kidneys, and immediately thrown out of the body.

We had intended to have laid down formulas for the analysis of the different fluids of animal bodies. But this article has already extended to such a length, that we conceive it necessary to bring it to a termination. We would recommend those persons who wish to acquire skill in this kind of analysis, to study a work on the subject published by Berzelius in 1806 and 1808, in two octavo volumes, and entitled *Föreläsningar i Djurkemien.* The rules of animal analysis are laid down in that book with all the requisite minuteness, and excellent examples are given by the accurate analysis of most of the human secretions and excretions. It is a serious injury to the progress of animal chemistry in this country, that this work has not been translated into the English language.

None of the readers of this article can be more sensible of its imperfections than the author of it himself. But it was impossible to remedy these imperfections without entering into details quite incompatible with the limits of a supplementary article,

Instead of a minute description of the method to be followed in the analysis of every kind of substance, which would have been requisite in a complete treatise on this subject, we have been obliged to satisfy ourselves with general observations on the mode of investigating some of the more prominent groups. We are not without hopes that these observations, limited and imperfect as they are, will be of some use to the young chemist; especially those that refer to the gases and salts, which we have treated somewhat more at length than any of the other departments. (J.)

Decomposition, Chemical || Delille.

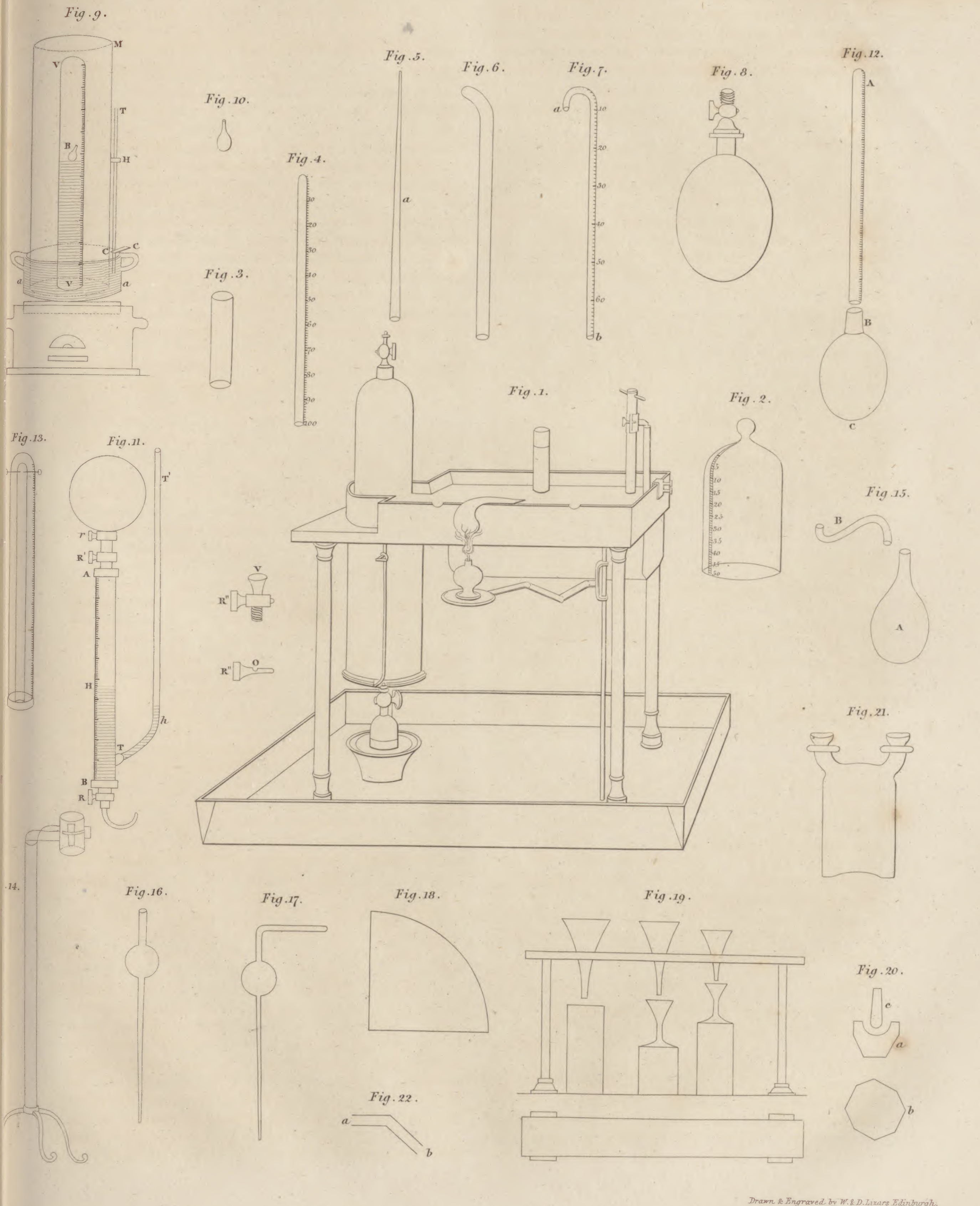
DELILLE (Jacques), early acquired deserved celebrity as the founder of a new school in French poetry, but, unfortunately, his ambition extended with his fame, till he left behind him as many didactic poems as Sir Richard Blackmore has epics, and, we suspect, the greater number of them are already almost as little known. The author of the *Jardins*, indeed, will always hold his rank among poets, but it would have been no great misfortune to his memory if he had written little more.

He was born on the 22d of June 1738, in the neighbourhood of Clermont in Auvergne. His father was a man of neither fortune nor family, but he was connected by his mother with that of the Chancellor de l'Hopitâl. With very slender means of support, he was educated at Paris, and made such a progress in his studies, as augured well for his future distinction. When his education was completed, he was forced to accept of a very low situation, as a teacher in the college of Beauvais, but this was soon exchanged for the more honourable station of Professor of Humanity at Amiens. After returning to Paris, where he likewise obtained a Professorship, he speedily acquired a considerable poetical name, and was encouraged, by the younger Racine, to give to the world a translation of the *Georgics* of Virgil, which he had begun at Amiens. This translation was a bold attempt for a French poet. The muses of that nation were but little conversant with a country life. They had been reared in courts, and seemed incapable of assuming any other tone than that declamatory one in which kings and princesses might be supposed, however erroneously, to give utterance to their tragic woes; or that elegant and complimentary style in which the interests, the intrigues, and the morality of polite life, find a much truer and more adequate expression. Racine and Boileau, in a word, had fixed the poetry of their nation; within the limits which they had prescribed for it, it was perfect in its kind, and this made it appear still more hopeless to attempt to extend it farther. Voltaire, indeed, had given a wider compass to the language of tragedy; in his spirit of universal dominion, he had attempted the epic, but had failed: he was more successful in transfusing into the guarded regularity of French poetry, some of the wilder graces and eccentricities of the Italian; but even he would have shrunk from the unprecedented audacity of walking his courtly muse over a ploughed field, or bringing her within the steam of a dunghill. We are told, accordingly, that he was greatly struck with the enterprise and the success of Delille, and that, without any personal acquaintance with our poet, he, of his own accord, recommended him and his work to the good graces of the Academy. It was not, however, till some years afterwards, that Delille became a member of that celebrated body. He now aimed at a higher distinction than even a finished translation of the most finished poem in the world could confer upon him; and in the *Jardins*, which he published a few years after his reception in the Academy, he made good his pretensions as an original poet. The mantle of the Roman bard still, indeed, seemed to enfold him, and, if we can pardon a few French prettinesses, there is no didactic poem in any language, we believe, which approaches so closely to the polish, the grace, and the tenderness of Virgil, as the *Jardins* of Delille.

It is an unfortunate thing for a poet to become too ambitious, especially if his former success renders him inattentive to the steps by which he was conducted to fame. After his *Georgics* had put him at the head of the poets of his country, Virgil, in obedience to the calls of gratitude and of patriotism, rather than of ambition, ventured upon his grand national epic: an arduous effort even for him! Yet by never losing sight for a moment of his own strength and his own weakness, he has been enabled, (although his heart never seems to have gone along with it, and he was at last, as is well known, quite dissatisfied with his own work,) to complete an undertaking which, in the judgment of posterity, has for ever encircled his modest brows with a glory, second only to that which beams from the divinity of Homer. His French disciple, who seemed for a time to be humbly treading in his steps, wanted, however, the composure of a Roman head. After the success of his *Jardins*, Delille appears to have forgotten where the strength of his own genius lay; that he was nothing at all if he was not cautious, select, elegant, and pathetic;—that the world did not expect to be deluged by his poetry, but to be refreshed by its gentle and winding streams;—that there was no necessity, in a word, for his writing a great deal, but the very greatest for his continuing to write inimitably well. The subject upon which he next laboured was an unhappy one. Without any great portion of *Imagination* of his own, he projected a poem on that vague and indeterminate theme: he sets out, accordingly, at a pitch which he cannot keep up;—he then loses himself in indistinct metaphysics;—and the want of any limit to his subject, tempts him into a wandering and interminable style of composition, which is at complete variance with every thing like point, polish, and elegance. Before he had gone far in the composition of this poem, which was not, indeed, published till after many of his other works, he made a voyage to Constantinople, in the train of the ambassador M. de Choiseul Gouffier. He did not lose this opportunity of visiting Attica and the Troad, and we might have hoped, that some glowing sketches of scenes so inspiring to a poet,

DECOMPOSITION, CHEMICAL

PLATE LXIX.



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would have relieved the heaviness of his *Imagination.* But the following is the only passage in all that long poem which pretends to catch any portion of their divine influence.

Lorsque de l'univers l'aimable enchanteresse
L'imagination, me porta dans la Grece,
Je ne m'attendais pas qu'un jour mes propres yeux
Verraient ces belles mers, ces beaux champs, ces beaux cieux;
Je les ai vus! Mon cœur a tressailli de joie:
Homere m'a guide dans les champs ou fut Troie.
Pour moi, ses vers divins peuplaient ces lieux deserts,
Et ces lieux, a leur tour, m'embellissaient ses vers.
Un delir charmant, qu'il m'inspirait sans doute,
D'enchantements sans nombre avait semé ma route;
Je ne demandais plus, pour traverser les flots
Ni le secours des vents, ni l'art des matelots;
Je disais aux tritons, aux jeunes nereides,
De pousser mon vaisseau sur les plaines humides.
Tout a coup sur ces mers, à mes yeux s'est montré
Un stupide Pacha, d'esclaves entouré;
Tout s'est desenchanté, &c.

In spite of this tremendous Pacha, whose stupidity appears to have been somewhat infectious, our poet, while he resided at Constantinople, was almost in the daily habit of passing over to the coast of Asia, and studying his poem amidst the inspirations of its splendid scenery. Yet we cannot be persuaded that his enthusiasm, amidst these classical regions, was very profound or genuine; if it be true that he stated it as one of his greatest enjoyments, while resident among them, that he could go every day to breakfast in Asia, and come back again to dine in Europe.

On his return to Paris he prelected, in his capacity of Professor, on the Latin poets, and was attended by a numerous audience, who were delighted, not only with his critical observations, but with his beautiful recitation. He indulged them, too, with his own verses; and in this way, we believe, the choice *morceaux* of his poem on Imagination were familiar to the public long before it came into their hands. Delille continued to advance in fame and fortune, though without hazarding any more publications, till the period of the Revolution, when he was reduced to poverty, and sheltered himself in retreat from the disasters which surrounded him. He quitted Paris, and retired to St Diez, the native place of Madame Delille, and here he completed, in deep solitude, his translation of the Æneid, which he had begun many years before. A residence in France soon, however, became very undesirable, and he emigrated first to Bâle, then to Glairesse in Switzerland; a charming village on the lake of Bienne, opposite Rousseau's island of St Pierre. Much delighted with this enchanting country, and with the reception which he met from its inhabitants, he occupied himself constantly in the composition of poetry, and here finished his *L'Homme des Champs*, and his poem on the *Trois Regnes de la Nature.* We have censured Delille for writing too much; but an excuse may be found for him in the horrors of the times, and the necessity of some object to interest his mind, and relieve it from the oppression of his misfortunes. He would probably have adopted a course more favourable to his fame, had not the Revolution sent him adrift upon the world. His next place of refuge was in Germany, where he composed his *La Pitié;* and finally, he passed two years in London, chiefly employed in translating *Paradise Lost.* In 1801, finding that he might return safely to Paris, he did so, carrying with him his immense *Poetical Encyclopædia*, and from that time he sent poem after poem into the world, till at last he himself quitted it on the first of May 1813, at the age of 75. In his latter years he had lost, in a great degree, his sight, which gave him an opportunity to open one of the cantos of his *Imagination*, with an imitation of that noble passage in which our sublime poet laments a similar misfortune.

Voila que le printemps reverdit les coteaux,
Des chaines de l'hiver degage les ruisseaux,
Rend leur feuillage aux bois, ses rayons à l'aurore;
Tout renait; pour moi seul rien ne renait encore.

Delille appears to have been a person of a very amiable and simple character; his conversation full of a child-like gaiety; his writings always moral and pious. He was a man, too, of courage and firmness. In his voyage to Attica, his little vessel was pursued by pirates, and very nearly overtaken. All on board were in consternation. The poet very coolly observed, " these rascals are not aware that I shall make them very ridiculous in an epigram." A finer instance of his resolution occurred during the tyranny of Robespierre. That wretch ordered him to compose a hymn on occasion of an impious fete, which Delille refused to do, and replied to the threats which were made him, *Que la guillotine etait fort commode, et fort expeditive.* Being still urged to comply, he did write an ode, in which he took occasion to paint (a theme we may believe not very agreeable to the heroes of the Revolution) the terrors which immortality held out to the guilty, and its consolations to the virtuous under misfortune. This was very noble; but, wearied out afterwards by his long banishment, he does not appear to have been equally sturdy when he put forth his poem of *La Pitié*, on his return to Paris. Unfortunately he had already given it to the London booksellers; and, in their edition, there were various attacks on the proceedings of Napoleon, and expressions of great devotion to the exiled family. But when he found himself under the Consular government, he made considerable alterations on his poem. It was published in Paris about the same time that it appeared in London; and, like the statue with two faces, it was quite a different thing, according to the side of the channel on which it was contemplated. On a general estimate of the genius of Delille, we must consider him as a poet of much refinement and delicacy; but of no great power or stamina. Upon the pleasing subject of rural life, he dilates with great beauty and felicity. There are, too, throughout his poems, very splendid descriptions of all kinds, but he weakens them constantly by diffusion; and there is very little art or elegance in his connections or transitions. He set out well, but he afterwards attempted more than he could compass. It is a pity that he was able to read any language but French and Latin, or that he should

have ever wandered beyond the precincts of nature and of Virgil. It has occurred to us in reading Delille, that, with all his beauty of versification, and occasional felicity of expression, he yet shows, in his later works especially, a great ignorance of the line of distinction between prose and poetry. This is a curious subject of discussion; and we know not that it has ever been accurately examined. There may be very eloquent and very animated prose, which yet, if versified, would make but indifferent poetry. Delille very nearly versifies some of the pathetic passages in Rousseau's *Heloise;* but in his hands they are any thing but poetical. On the other hand, there are poems on subjects that are more naturally treated in prose, but which, by the art of the poet, acquire the character of poetry. The satires of Horace, which he himself calls "*Sermoni Propiora*," Dryden's *Religio Laici*, and still more the *Epistles* of Pope and Boileau, have all, doubtless, a poetical character, although there is in them no passion, and very little imagery. Didactic poetry, in general, is an invasion upon the precincts of prose composition; but how wonderfully have some poets invested it with the attributes of the highest inspiration! One half of Lucretius is mere reasoning; yet even in his reasonings we see a poet. There is the animation, the diction, the rapidity of poetry; and that overflowing of mind with which he is constantly breaking out of his reasonings, and running into the most brilliant conceptions and pictures, is its very soul. Virgil, too, in his *Georgics*, is poetical from beginning to end. No man who ever wrote seems to have seen more distinctly than this great master what it is that peculiarly constitutes poetry, or was so capable of diffusing it over the most unpromising parts of his subject. Perhaps the charm consists very much in selection. A prose writer accumulates image upon image, when he wishes to make a forcible impression; translate these into verse, and some of them will appear insignificant, some of them low, and the quantity of them tedious. This is often the effect of Delille's descriptions. A poet like Virgil, again, fixes upon some one striking feature of the conception which he wishes to impress—some thought that breathes, and word that burns; and giving us these, he not only gives us the image which he expresses, but the full force of many kindred images which are kept behind, but which our imaginations, when thus seized, can easily body out for themselves.

Delille has left behind him little prose. His preface to the translation of the *Georgics* is an able essay, and contains many excellent hints on the art and the difficulties of translation. He wrote the article *La Bruyere* in the *Biographie Universelle.* The following is the list of his poetical works: 1. *Les Georgiques de Virgile, traduites en vers Françaises.* Paris, 1769, 1782, 1785, 1809. 2. *Les Jardins, en quatre chants*, 1780. Nouvelle edition, Londres, 1800; Paris, 1802. 3. *L'Homme des Champs, ou les Georgiques Françaises*, 1800. 4. *Poesies Fugitives*, 1802. A Collection given under the title of *Poesies Diverses*, 1801, was disavowed by Delille. 5. *Dithyrambe sur l'Immortalité de l'Ame, suivi du passage du Saint Gothard;* poeme traduit de l'Anglais de Madame la Duchesse de Devonshire, 1802. 6. *La Pitié;* poeme en quatre chants. Londres et Paris, 1803. 7. *L'Eneide de Virgile, traduite en vers Françaises*, 1805. 9. *L'Imagination, poeme en huit chants*, 1806. 10. *Les Trois Regnes de la Nature*, 1809. 11. *La Conversation*, 1812. (v. v.)

DEMERARA or DEMERARY, a colony belonging to Great Britain, in the northern part of South America. It is now composed of what formerly constituted the two governments of Demerara and Essequibo; both of which having been permanently secured to Great Britain by the peace of 1814, have been formed into one settlement, and now constitute but one province. Stabroek, the principal city, and the seat of the government, is in lat. 6° 46′ north, and 57° 45′ west longitude from London. It is bounded on the east by a line drawn from the mouth of Albany creek, in a south-east direction, which divides it from the British colony of Berbice, and on the western side by the river Pomaron, which divides it from Spanish Guyana. Its northern boundary is the Atlantic Ocean, and its southern is undetermined.

On this coast the tides rise to the height of from sixteen to twenty-four feet. The river Demerara has a bar across its mouth, which prevents ships of large burden and correspondent draught of water from entering it. Vessels not drawing more than fourteen feet may be loaded in the river; but those of greater draught must complete their loading without the bar. At Stabroek there are convenient wharfs towards the river, but they are only safe for small craft to lie alongside them, on account of the withdrawing of the tide, and the declivity of the bank. Vessels, therefore, are compelled to load and discharge their cargoes in the middle of a rapid stream. The other river, the Essequibo, has no bar, and is easily entered by the largest merchant ships, but they must also be loaded and unloaded in the stream. Although the cultivation in Demerara at present exceeds that on the Essequibo, yet the greater depth of water in the latter river, and the absence of a bar at its entrance, will, at no distant period, raise its settlement above that on the former river.

The river Demerara is navigable for ships, about fifty miles above Stabroek, and perhaps even higher; but as there are no plantations at a greater distance, no accurate survey of it has been taken. At 130 miles from its mouth are considerable cataracts, beyond which the Europeans have not explored; but the Arrowauk Indians, who descend in large canoes, represent it as accessible above the cataracts, to a much greater distance than they are from the sea. Information respecting the river Essequibo is equally obscure. About sixty miles from its mouth it is divided into three branches, the easternmost of which proceeds from the supposed lake Parima, on which the imaginary city El Dorado was expected to be found. Another branch called the Cayony, is supposed to be occasionally connected with the river Orinoco; but the woods are so difficult of access, the swamps so extensive, the country so unhealthy, and the inhabitants so irritable, that probably many years must elapse before our geographers can become acquainted with the origin and

Demerara.

courses of these vast rivers which water the whole of Guyana.

History.

The first settlements on the river Essequibo were made by the Dutch in 1706, and those on the Demerara in 1746. But the colonies made a very slow progress in cultivation for a long period after their first establishment, and even in their origin a considerable portion of the largest capitals was furnished by British subjects. They continued to languish during the whole of the first few years of their settlement, solely from the want of capital; since the fertility of the soil seems to have been known from the commencement. In the year 1781 they surrendered to a small British squadron, and at the conclusion of the peace in 1783 were given back to the Dutch. In 1796 they were again taken, and at the peace of Amiens again given up. During this latter period very considerable British capitals had been embarked in the cultivation of the colony, the proprietors of which became much embarrassed by its cession; but the progress of improvement was scarcely arrested, when the war, again breaking out, it was surrendered to a British armament, which, though incompetent to take forcible possession, was sufficient to justify the surrender of its willing inhabitants.

As the progress of the settlement had been principally owing to British capital, it seemed but just that it should be permanently ceded to the nation with whom it was most intimately connected, and from which its prosperity had arisen; and accordingly the King of the Netherlands has, by the last treaty, given it up permanently to Great Britain.

As the cultivation is solely carried on by the labour of negro slaves, the importation of that unfortunate race, from the time it came last into our possession, until the abolition of the slave trade, is the most certain criterion of the increase of cultivation.

Slaves imported into Demerara and Essequibo.

		Slaves.
From 1st Oct. 1803, to 5th Jan.	1804	5876
	1805	5458
	1806	2249
	1807	2211
	1808	1422
		17216

Productions.

Though all the tropical productions are raised in Demerara with great facility, the principal articles sugar, coffee, and cotton, seem to be more exclusively produced than in our other colonies. Of late the improvements made in their sugars have been considerable, and the cultivation of that article, at present, very much predominates.

Provisions for the maintenance of the negro population are wholly raised within the colony; which, combined with the great fertility of the soil, gives such a superiority over the islands which have been long cultivated, that if the removal of the slaves from one colony to another were allowed, now that it is become securely British, a very large proportion of the negroes from the islands would be immediately transferred by their masters to form new plantations on the banks of the Berbice, the Demerara, and the Essequibo.

Demerara enjoys, in common with the other colonies in Guyana, another advantage over the islands, in the abundance of timber which its forests furnish. The trees on the low grounds, near the settled parts, are, indeed, of such hard wood, as to be worked with difficulty; but they supply all the staves necessary for their sugar casks. Other kinds of timber for rum puncheons and for their buildings are imported from North America at present; but by ascending to a higher level of country, a sufficiency of proper trees might be cut down, and conveyed by the river, to supersede the necessity of depending on importation.

Climate.

Though situated almost under a vertical sun, the country is more healthy than any of the islands, which probably arises from the greater equality of the temperature. The constant regularity of the trade-winds during the day, and of the land breezes which succeed them in the evening, joined to the invariable length of the nights, with their refreshing dews, renders the heat far from excessive; and Europeans find it less oppressive than even in Barbadoes, which is accounted the most temperate of all the tropical islands.

The only division of seasons known is the wet and the dry, each of which occurs twice in the year, and continues about three months. In the month of May the showers begin, and gradually increase until the month of June, when the rains become incessant, frequently accompanied with most violent thunder. In the beginning of July the rain gradually diminishes, and entirely ceases by the commencement of August. The same course is observed as the sun approaches the tropic of Capricorn, but the rains are of shorter duration, and of less force, than when the sun advances towards the tropic of Cancer, and are seldom attended with any thunder. From the peculiar character of the seasons, the operations of agriculture proceed with equal steps, and each half of the year is alike favourable for planting and harvesting the produce.

Soil.

The soil in this colony is perhaps equal in fertility to any in the world. It has a blue marly appearance, mixed in part with the remains of sea shells; and has been transported as manure for the lands in Barbadoes, which had been previously exhausted. It has been known to produce thirty crops of rattoon canes in succession, without replanting, whereas in the islands they seldom calculate on more than two. The cultivators have had recourse to various expedients for diminishing the excessive richness of the soil. This is sometimes effected by cropping it for two or three years with plantains, and afterwards with sugar canes; but the first, second, and sometimes even the third crop of canes are so luxuriant, as to be unfit to make sugar, and are therefore used only for rum.

The whole of the cultivated land, extending about fifty miles from the sea-shore inwards, is flat and level, without a single hill, and so low, that during the heavier rainy season, it is frequently covered with water to the depth of two

Demerara.

feet. This produces an effect similar to the prolific overflowing of the Nile. It deposits a rich muddy clay, which has formed a stratum of twelve or fourteen inches in depth, and is perhaps the cause of the fertility which we have already noticed.

Plantations.

From this low situation of the ground, the planters have been compelled, in bringing the land into cultivation, to surround it on two sides with deep dikes, to convey the water to the river, and to construct sluices, which resist the tides, and prevent the sea water from flooding their lands. Besides those trenches which convey the backwater from the plantations, each estate is intersected with smaller trenches, by means of which, in small flat-bottomed boats, the whole conveyance of the produce, from one part of the estate to another, is effected. The canes are thus carried from the field to the sugar mill and the still-house; which much diminishes the labour of horses and mules. The plantations are divided into beds of thirty-two feet in breadth. Between each of these is a small trench or ditch, dug two feet in width and three feet in depth; the mould which is removed in forming these ditches is thrown on the beds, which are thus raised above the natural level of the surface. On these beds the cotton-trees are planted in rows at six feet distance, in the richest soil, and where it is supposed to be less rich at a somewhat greater distance. The coffee trees are planted in rows from nine to twelve feet asunder, and, as they will only flourish under the shade, the intermediate spaces are filled either by plantain trees, or the *bois immortel*, which grows to the height of twelve or fourteen feet.

Negro Population.

The cultivation of this settlement requires the application of a considerable portion of manual labour, and its future increase, notwithstanding the fertility of its soil, must depend on the quantity of labour that can be applied to it. The keeping up the embankments which prevent the backwater from overflowing the estates, is a great and constant labour, and the eradicating weeds, which grow as luxuriantly as any other crop, requires no inconsiderable attention and exertion. Although the colony contains nearly 62,000 negro slaves, yet they must, from natural causes, for some time diminish every year; whatever provision may be made for their subsistence, or whatever alleviation may be afforded to their toil. It is well known, that, from obvious causes, as long as the slave trade continued, a far greater proportion of males than of females was imported. Without a tolerable equality between the sexes, it is not possible that population should increase; but when the number of males very far exceeds that of the females, it must necessarily diminish till this equality is reached. We cannot exactly ascertain what are the relative numbers of the two sexes in Demerara; but it is certain that the males far exceed the females; according to one calculation, in the proportion of four to one; according to another, in the proportion of five to two. Whatever the disproportion may be, it is clear, however, that the increase of population must depend on the number of females. The males, who are now the greater number, will diminish with most rapidity, but whenever the period shall arrive in which the females shall equal the males, or even somewhat exceed them, the course of population may take an opposite direction, and begin to increase. This, however, supposes that there shall be a sufficiency of food, that the labour be not excessive, and that the promiscuous intercourse between the sexes be abolished, which, though almost a necessary consequence of the inequality of the sexes, is the bane of happiness, and tends to increase the evil of depopulation.

If this view be correct, we must, for a period of years, look to a gradual diminution of the labour at present applied to the soil. When the sexes shall reach nearly to equal numbers, we may calculate that the planters will have been taught, by the gradual decrease of their labourers, the value of their strength and lives; they will, therefore, for their own interest, apportion both their labour and their subsistence, in such a manner as shall most effectually promote their happiness, and consequently their increase.

It is only from the increase of the negro population, and from its increase in the way we have pointed out, that any hopes can be entertained of the extension of cultivation in these provinces. The labour of the fields cannot be endured by the whites; the attempts to cultivate by Chinese have hitherto failed; and no new attempts of the kind seem likely to be made.

Aboriginal Inhabitants.

The aboriginal inhabitants, whether Caribs or Arrowauks, have no disposition to labour. They are of feeble frame and indolent disposition, and obtaining the means of bare subsistence with little effort, no inducements are likely to lead them from their accustomed roving independent life, to those settled and quiet habits which cultivation requires. The present utility of the Indians to the colony, arises principally from the aversion and even hatred which subsists between the Indian and negro races. This converts them into useful allies, whenever an insurrection of the negroes is contemplated or commenced, and prevents the desertion of the latter, from the knowledge that, if they escape into the woods, they can scarcely avoid being captured by the roving Indians, and conducted back to receive from their masters the assigned punishment. The Indian tribes, bordering on this colony, have been often described; we shall, therefore, only say of them, that their numbers are small, and gradually diminishing, and that when they visit the Europeans on the coast, they appear mild and gentle towards them; but discover, by every significant symptom, their hatred and disdain of the negroes, with whom nothing can induce them to associate, except the thirst for spirituous liquors, to the love of which they are addicted, with all the characteristic greediness common among savages.

The government of the colony has not been inattentive to that important branch of internal policy which regards roads, bridges, embankments, and sewers for draining. The roads are kept in excellent order, and by the help of a sewer tax, the other rural public works are maintained on a respectable and beneficial footing.

Laws.

By the terms of the capitulation, the Dutch colo-

nial laws govern in this settlement. At first the Dutch proprietors were the most considerable, and consequently it was but right that they should be ruled by laws, with whose forms and principles they were familiarly acquainted. As the British proprietors have increased, and now far outnumber the Dutch, the same laws have been continued. They are so interwoven with all the institutions and habits of the colonists, and the security of the property so much depend upon them, that no considerable alteration could be made without rendering the right to much of the property unsettled; therefore, it is probable they will continue unchanged; especially as it is allowed by all the colonists, that, when honestly and skilfully administered, the laws of Holland are well calculated for the circumstances of the country. When the colony first came into possession of the British, the proceedings in the courts of law were all carried on in the Dutch language; and this created suspicion in the British inhabitants, whether well or ill founded, that no justice could be obtained in the courts between a British and a Dutch party. Since the colony has become permanently attached to the British government, the English language has been ordered to be used in all law proceedings, and by the advocates; and, though this has produced the whimsical exhibition of Dutch lawyers studying the English language, and English lawyers studying Dutch law. yet the practice has succeeded so far as to reconcile the inhabitants to the system, and to give them confidence in its purity.

A practice rather than a law, for it seems to have grown up in the colony, and become established without any express enactment, deserves to be noticed on account of its importance to European capitalists who may be tempted to invest money on colonial securities. No man can grant a mortgage on his landed property until he has advertised in the *Colonial Gazette* his intention to do so. When it is so advertised, any one of his simple contract creditors may effectually stop the mortgage till his debt is satisfied. The reason of this rule is, that a West India proprietor may not be enabled to go to Europe,—dissipate his property there by a mortgage,—secure those who have supplied him with the means of supporting his extravagance, and thus defraud those who, during his absence, have supplied his estate with the necessaries which were indispensable for its cultivation. As far as this rule tends to secure the West Indian creditor, it ought not to be complained of, nor perhaps has the European capitalist, who lends his money on a colonial security, without clearly understanding the laws or rules of the colony in which the security exists, any great reason to complain. It has, however, frequently occurred, that mortgages upon estates in the Dutch colonies have been negociated in England, the money advanced, and the security supposed to be perfected, when a number of creditors within the colony, with simple contract debts, have appeared, whose claims were equal there to those of the mortgage. These must be satisfied before his security can be valid, or if he forecloses, they must be admitted with him as concurrent creditors.

The Governor of Demerara is maintained by a salary drawn from England. The internal government is supported by taxes paid by the inhabitants. Besides that for keeping the sewers and dikes in repair, which is before noticed, an annual tax of about 5s. Sterling on each slave is levied. The accounts are kept in Dutch money, and exchanged in their European transactions, into Sterling at very variable rates of exchange. A quantity of silver, colonial money, has been coined in England for the use of the province, which forms the current money in all small negociations. The value of the pieces are about 3s. and they are found highly convenient in the exchanges of property within the colony.

The free inhabitants of the colony, including whites, mulattoes, and blacks, scarcely exceed 3000, or not more than one in twenty to the number of slaves; a greater disproportion than exists in our colonial islands. The greater part of these are in Stabroek, the capital, which is the seat of government, and the head-quarters of the armed force. It is a small town, defended by a fort. Its inhabitants of all kinds are about 5000. The customhouse is here, the fees of which, with all the care of the commissioners who lately went from England to regulate them, are still enormous.

Natural History.

As no part of this colony has been explored with much attention beyond the limits of the cultivation of sugar, coffee, and cotton, we know little of the mineral history of the country. Above the cataracts, there is abundance of red and white agates, which remain untouched by the natives, from superstitious fears, which represent them as dedicated solely to the service of some magical invocation, practised by their priests. There are likewise a variety of stones, which appear to contain valuable ores, and probably gold and silver may be hereafter discovered. It is possible that the stories collected by Sir Walter Raleigh from the concurrent reports of various natives, though greatly exaggerated, may not have been altogether without foundation. We are, however, very ignorant on this subject, and there is no immediate prospect of our ignorance being removed.

The cocao, coffee, plantain, banana, and cocoa trees have been so often described, that any extended notice of them would be unnecessary. The trees peculiar to this country deserve shortly to be remarked. The *pigeon* or *Angola pea tree* is a branchy shrub, about nine feet high, covered with smooth, long, narrow-pointed leaves. Its flowers are of the papilionaceous kind, and are succeeded by numerous pods, of a russet colour, shaped like those of the English pea, but rather more flat. These are divided into four or five cells, containing the peas, which, though somewhat astringent, are agreeable and nutritious. The *Arnotta* or *Roucou tree* is usually about nine feet in height, with long narrow green leaves, in alternate order, the middle and transverse ribs of which are of a red colour. The flowers are pentapetalous, and of a bluish yellow colour. From the middle of the petals rises a style containing the embryo of the pods, which incloses that containing the seeds. These, when ripe, are covered with a beautiful crimson pulp. The seeds macerated in the juice of lemons, in which the gum of the manna tree has been dissolved, yields

Demerara.

the celebrated pigment with which the natives decorate their bodies. The *vegetable musk* plant is about four feet high; it produces a pod whose cavities are filled with small oval seeds of a dark brown colour. These diffuse the smell of musk, and are replete with an oil used as a specific for the bite of the venomous snakes, and for that purpose taken internally, as well as applied externally to the wounded part. The *silk cotton tree* is about 100 feet in height, and twelve feet in circumference; its trunk continues undivided to seventy or eighty feet from the ground. Within a pod of a conical form, about four inches in length, is contained a short fine silky filament, the crops of which are triennial. The trunks of the trees, hollowed by fire, furnish canoes to the Indians, frequently of seventy or eighty feet in length. *Gum Anime* is the product of a tree forty feet high, with few leaves, and those near the top; they are small, a dark green, and oval. From incisions made in this tree, a whitish resinous gum exudes, with a grateful smell and pleasant taste. It is used by the natives as a remedy for pains in the stomach, rheumatism, and headaches, and in Europe for varnishing carriages. Troolies are perhaps the largest leaves that have been hitherto noticed. Each leaf is supported by a single stem, arising immediately from the root, which runs through the whole length of it. These stems are very strong, are about three inches in circumference at the root, and gradually taper to the termination of the leaf. The fibres are strong, and closely connected from one end to the other, without any sections or divisions. Ten or twelve of these leaves usually grow in one cluster. They are commonly from twenty to thirty feet in length. The flowers are clusters of a yellowish white, and produce a great number of large globular nuts, covered with a thick hard black shell, through which there is a hole to the kernel. It resembles a hand grenade in weight, size, and hardness. As the leaves of this singular plant will last many years, they are used for the covering of the houses, and are found to be a protection against the most violent rain.

The animals of Demerara most common are those whose original races were imported from the ancient continent; horses, asses, cows, sheep, and hogs. These scarcely vary from the same animals in Europe, except that the sheep, as in all the tropical countries, have their wool converted into hair.

The native goat of Guyana is of a much smaller size than the goat of Europe; its hair is similar, its horns slender and incurvated downwards, and it is more prolific than the European breed, usually producing from three to five kids at each birth. There are two kinds of deer, one of the same size as those of Europe, the other about one-third less. They feed on the meadows, and approach very near to the plantations, but, being very active and fleet, can with difficulty be caught, unless they get into the rivers, when they are easily taken by the Indians. The two kinds of wild hogs, the pecary and the warre, are very abundant; the former having on its back a gland which was formerly mistaken for its navel, which secretes a milky liquid of a musk-like smell, and which, unless removed the instant it is taken, communicates its flavour to the whole carcass, rendering it disgusting to European palates.

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The monkeys of all kinds are very numerous, from the ouran outang, the largest, to the sacca winkee, which does not exceed, exclusive of its tail, six inches in length; its tail is about nine inches long. The tigers, which are neither so strong nor so fierce as those of Africa, frequently make incursions on the plantations, and carry away hogs, sheep, and other domesticated animals, and sometimes have attacked, and even destroyed men.

The diseases to which the inhabitants are subject differ but little from those experienced in other tropical countries; but the leprosy is much more frequent, and more violent, than it is known to be in any other situation. It is supposed to be highly infectious, and those afflicted with it are carefully sequestered from society in remote situations in the forests. The yellow fever, though it has sometimes visited Demerara, has been less extended and less fatal than in the more northern part of America, whether insular or continental.

Natural History of Guiana, London, 1769.—Bolingbroke's *Voyage to Demerary*, 1807.—Stedman's *Surinam*, 1806.—*Parliamentary Papers*.—*Various Manuscripts*. (W. W.)

DENBIGHSHIRE, a county of North Wales. This district, which in Welsh is called *Sir Dinbech*, was, in the time of the Romans, included in that part of Cambria occupied by the Ordovices; and formed a portion of Venedotia, one of the minor partitions of Britannia Secunda.

Denbighshire.

Extent and Boundaries.

The figure of Denbighshire is very irregular; continually varying in length and breadth. Its length from north-west to south-east is about 48 miles, and its greatest breadth 20 miles, but in some parts it is not more than eight miles. It is 170 miles in circumference; and is computed to contain 731 square miles. On the north it is bounded by the Irish sea; on the north-east it is separated from Flintshire by the river Dee; on the south-east by Shropshire; on the south by Montgomeryshire and Merionethshire; and on the west it is separated from Caernarvonshire by the river Conwy.

Divisions.

This county is divided into six hundreds,—Isdulas, Isaled, Ruthin, Yale, Bromfield, and Chirk. It includes one borough; six market towns, viz. Denbigh, Ruthin, Wrexham, Holt, Llangollen, and Llanruost; and consists of fifty-seven parishes. It is included in the Chester circuit; and, with respect to ecclesiastical jurisdiction, it is under the Archbishop of Canterbury, partly in the diocese of Bangor, and partly in that of St Asaph; the deanery of Duffryn Clwyd being in the former see. It returns two members to Parliament, one for the county and another for the towns of Denbigh, Ruthin, and Holt. The borough of Denbigh affords the title of Earl to the noble family of Fielding; and that of Yelverton derive their title of Baron from Ruthin.

Soil and Surface.

The surface of the country is much diversified; affording a great variety of scenery. The western parts are rather mountainous, abounding with hills, upon which are small lakes. The northern parts have the same character, excepting that tract which stretches from Abergeley along the sea coast, which

gradually slopes into the extensive plain of Morva Rhyddlau. The celebrated Vale of Clwyd is a fine scene. The land spreads on each side of a river of the same name, from its source unto the sea; a distance of more than twenty miles, and from five to seven in breadth. The mountains, which rise on each side, with their brown and barren summits, form a fine contrast with the verdant meads and luxuriant fields, which gratify the sight as far as the eye can see. Towns, villages, and seats, thickly studded over its surface, tend still more to enliven the scene, and beautify this charming vale. The land included between the Alun and the Dee is fertile, pleasant, and highly productive. The central parts of the hundred of Isaled consists of bleak and barren hills, and the southern comprises a large tract of land, devoid of wood, and productive of peat only, which, principally, affords the fuel of the inhabitants. Yale is a mountainous region, chiefly covered with heath, forming an excellent cover for grouse. Bromfield, the most important part of this county, in population and wealth, though sharing in the mountainous character of the rest, furnishes a great portion of rich land.

Climate. The irregularities of the surface and the variety of the soils produce a considerable difference in the climate of Denbighshire. On the hills the air is sharp, being deprived of its softness in its passage over Snowden and its neighbouring hills. Still it is reckoned salubrious. The atmosphere in the vales is milder. Duffryn Clwyd, being open to the sea, and defended by its mountain barriers, is proverbially celebrated for its salubrity. The inhabitants of this district are remarkable for their bright complexion, cheerful countenances, and sound constitutions,—a display of vivacity in youth, and a vigour in age, not possessed in less favoured situations; longevity, therefore, ceases to be remarkable, because it is here a common occurrence.

Rivers. The principal rivers of this county are the Clwyd, the Conwy, and the Dee, neither of which are navigable in those portions which pass through Denbighshire. The lesser are Ceriog, rising on the western side, and forming a junction with the Dee, near Chirk Castle; the Alun, commencing from Llandegla, and after a most circuitous route falling into the Dee, a little below the town of Holt.

The Ellesmere Canal passes through the southern part of the county; but there is a great difficulty in obtaining a sufficient supply of water to keep it navigable.

Minerals. Rich veins of iron and lead ore, and coal, have been found in divers places; and mines of these substances have been opened in several districts. Slate of a durable quality is worked in the southern parts, and meets with a great demand. Limestone is abundant; and freestone and other silicious substances are obtained in various parts.

Agriculture. In agricultural improvements, few counties surpass Denbighshire. The encouragement given for the amelioration of the soil, by the establishment of two Agricultural Societies, one in the Vale of Clwyd, and another in the neighbourhood of Wrexham; together with the co-operating effects produced by Sir Watkin Williams Wynne's show of cattle and sheep, with a distribution of prizes on the occasion, annually held at his seat, Wynnstay, is very visible in the county. It is stated to contain 410,000 acres, of which 150,000 is arable land, and 250,000 is pasturage. The roads also, which used to be very bad, have been much improved during the last few years.

The native horses are of a small size, but exceedingly hardy. The cows are generally of the black kind, low in stature, and yielding milk of an excellent quality. The sheep are the light horned sort, producing wool well adapted for the manufactures of the country. The goat, superior in size, and in the length and fineness of its hair, to most other countries, is found here in its ferine and domesticated state. In an agricultural point of view, the chief products are cattle, corn, and cheese. The latter is in some parts not inferior to the best Cheshire.

Manufactures. Its manufactures chiefly consist of coarse cloth, made in the parish of Glynn; of flannels, wrought out of the country wool; of cotton twist, and Angola hose, in the town of Denbigh; of a small quantity of iron; and of a few harps at Llanrwst.

Manners and Customs. Among the customs peculiar to this county, in common with other parts of Wales, are those pertaining to marriages and burials. Their weddings are thus conducted: When the marriage is agreed to be celebrated, a *bidder*, that is, one whose charge is to *bid* or invite the guests is appointed. He must be a person of respectable character, and as well gifted with eloquence and address as can be procured; as on his abilities the number of guests chiefly depends. He is to be sufficiently skilled in pedigrees, and family anecdotes, in order to be able to introduce compliments derived from these sources. The purport of his bidding, is to request the attendance of the friends of the young couple, and their benevolent presents, in order to enable the new married pair to begin life with comfort and prosperity. These contributions are some article of furniture, or money; and are regularly repaid, by gifts of a similar kind, on a like occasion. By this custom, a deserving young couple of the lower class are sometimes set up in a state of comparative wealth.

Previous to a funeral, it is customary, when the corpse is brought out of the house and laid upon a bier, for the next of kin to distribute bread, cheese, and beer over the coffin, to some poor persons of the same sex, and nearly of the same age as the deceased. This done, all kneel down, and the minister repeats the Lord's Prayer. At every cross way they stop, and the same ceremony is repeated, till they arrive at the place of interment. The funerals are generally attended by immense crowds of people of both sexes. All the graves are planted with the choicest evergreens and flowers, so that a church-yard has all the appearance of a beautiful and well-managed flower-garden.

The peasantry of this county are firm believers in *Fairies*, a diminutive race, clad in green, who hold their merry dances invisibly by moonlight; footing to lyric measures on the verdant turf of their mountains, leaving their marks, in darkened circles, to the admiration of the beholders. Allied to this race are the *Knockers*, a species of aërial beings, who, the

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miners say, are heard under ground, and by their noises, pointing out to the workmen the place where a rich vein of ore lies hid. The corpse candle, a light proceeding from the dwelling of a person who is shortly to die, to the church where he is to be buried; witchcraft, and the second-sight, are also articles of the firm belief of the lower class.

Antiquities.

Denbighshire contains several remains of ancient castles; that near the county town has been compared, with respect to its situation, to Stirling. It is placed on the summit of a lofty hill, assuming at a distance a most imposing appearance. From its present remains, it appears to have been a superb structure; and from the strength of its position invulnerable, but to heavy artillery, and irreducible, except in cases of treachery or famine. It is supposed to be of British foundation. The castle of Ruthin is built of red stone; and was erected in the time of Edward I. It stood on the side of a hill, fronting the vale to the west. The remains of this once proud pile consist of a few fragments of towers and fallen walls, reduced nearly to the foundations; and the area, at present, comprises a meadow, fives-court, and bowling-green. There are also the remains of a castle at Chirk, on the line of Offa's dike; another at Holt, built by Earl Warren, in the reign of Edward I. whose remains are now little attractive.

Its ecclesiastical antiquities consist of the remains of St Hiliary's Chapel, founded in 1579, by Dudley Earl of Leicester, and a priory of Carmelites, or White Friars, in the town of Denbigh. Llan Eqwert Abbey, a fine picturesque object, was a house of Cistertians founded in 1200; generally known by the name of Valle Crucis. Wrexham Church, formerly collegiate, the glory not only of the county, but ranked among the wonders of Wales, was erected about the year 1472; but the tower does not appear to have been finished till 1506. It exhibits a specimen of the chaste proportions and moderate decorations of Henry VII.'s time.

Among the modern buildings Wynnstay Hall, the hospitable mansion of Sir W. W. Wynne; and Chirk Castle, the seat of the Hon. Mr West, deserve particular notice.

Population.

The population of Denbighshire, according to the different returns, is as follows;—in the year 1700, it amounted to 39,700; in 1750, to 46,900; in 1801, to 62,400; and in 1811, to 66,400, inhabiting 13,000 houses. (Y. Y.)

DENINA (Charles John Maria), an eminent Italian writer, was born at Revel, in the principality of Piedmont, in the year 1731. Having studied at Saluzzo, he was about to enter into the order of the Grand Augustines at Ceva, at the age of fifteen, when one of his uncles appointed him to a benefice. He accordingly assumed the ecclesiastical habit, and remained two years at Saluzzo, when he learnt a little divinity, and acquired a knowledge of the French language, through the medium of a Swiss officer. In 1748, he obtained an exhibition, which enabled him to prosecute his studies at the provincial college in the University of Turin. Some time afterwards he took orders, and in 1753 was appointed Professor of Humanity at Pignerol. In consequence, however, of a quarrel with the Jesuits, he was obliged to quit Pignerol and the royal schools, and was sent to the schools of an inferior order. In 1756, on taking his degree of Doctor in Theology at the Palatine Schools of Milan, he printed his first work; a Theological Tract. After this he was restored to the Royal Schools, and was appointed extraordinary Professor of Humanity and Rhetoric at the Superior College of Turin. Six months afterwards he had the offer of the situation of an ordinary Professor at Chamberry, which he refused. About this time he projected, but did not execute, a work on the literary history of Piedmont. His discourse *On the vicissitudes of Literature*, which was printed in 1760, attracted a considerable degree of attention, and drew upon him the vengeance of Voltaire, who attacked him in his *Homme aux quarante ecus*, published in 1767. The publication of the first volume of his great work, *On the Revolutions of Italy*, obtained for him the Professorship of Rhetoric in the Superior College of Turin; and twelve months afterwards, on the publication of the second volume, he was preferred to the chair of Italian Eloquence, and of the Greek Language at the University. The third volume, which was published in 1771, was still more favourably received than the preceding; while, at the same time, it tended to augment the number, and to increase the virulence of his enemies. The misfortune, however, which he now experienced, was partly occasioned by his own indiscretion. A manuscript, containing some obnoxious opinions, which he had entrusted to Cambiagi at Florence, having been published by authority of the Tuscan Censors, but without that of the Censors of Turin, Denina was pronounced to be guilty of an infraction of the Piedmontese laws, and punished with great severity. His book was suppressed, and he was compelled to pay the costs. He was then banished to Vercelli, and afterwards received orders to retire to his native province. Denina's friend, the Abbot Costa D'Arignan, undertook his defence, and procured the restoration of a part of his annual pensions, with permission to return to Turin.

Denina.

In 1782 he repaired to Berlin, having, before his departure, received the honorary title of Librarian to the King of Sardinia. On his arrival at Berlin, Frederick II. appointed him a member of the Royal Academy; but he never became a favourite of that prince. He continued to reside in Germany for many years, where he occupied himself with literary pursuits, and published a variety of works. Being at Mentz, in 1804, he was noticed by Napoleon Buonaparte, who, in the month of October of that year, appointed him his Librarian. Denina accordingly went to Paris, where he continued to reside until his death, on the 5th of December 1813.

Denina is esteemed one of the most distinguished of the later Italian authors. The work upon which his reputation is principally founded is his *History of the Revolutions of Italy*, of which an improved edition was published at Turin in 1782, in five volumes 4to. In this work the facts are related with accuracy, and the narrative exhibits considerable talents for history. Some able critics in the Italian language have remarked, that there is a great differ-

ence between the style of this work, and that of the other writings of the same author; and Denina acknowledged, that he had submitted his history to the review of his friend the Abbot Costa d'Arignan (afterwards Cardinal and Archbishop of Turin), who made a good many judicious corrections.

The following is a list of his other works. *De Studio Theologiæ et norma fidei*, 1758, 8vo. *Discorso sopra le vicende della letteratura*, 1760, 12mo, which was reprinted, with additions, at Glasgow, in 1763, and has since gone through several editions. *Lettera di N. Daniel Caro* (the anagram of Carlo Denina), *sopra il dovere de' ministri evangelici di predicare colle istruzioni, e coll' esempio l'osservanza delle leggi civili, e specialmente in riguardo agl' imposti*, Lucca, 1762, 8vo. *Saggio sopra la letteratura Italiana, con alcuni altri opuscoli*, Lucca, 1762. This work is a supplement to the first edition of his *Revolutions of Literature*. *Delle Lodi di Carlo Emmanuele III. re di Sardegna*, 1771, 4to and 8vo. *Panegirico primo alla Maesta di Vittorio Amedeo III.* Turin, 1773, 4to and 8vo. *Panegirico secondo alla Maesta di Vittorio Amedeo III.* 1775, 4to and 8vo, with notes. In 1777, he composed a third panegyric on the same prince. *Bibliopea, o l'arte di compor libri*, Turin, 1776, 8vo. *Dell' impiego delle persone*, Florence, 1777. This was the work which gave so much offence, and occasioned the persecution of the author. It was reprinted at Turin, 1803, in 2 vols. small 8vo. *Istoria politica e letteraria della Grecia*, Turin, 1781–82, 4 vols. 8vo. Reprinted at Venice, 1783. *Elogio storico di Mercurino di Gattinara*, Turin, 1782, 8vo. *Elogio del Cardinal Guala Bichieri*, 1782, 8vo. *Discours au Roi de Prusse sur les progres des arts*, 1781, 12mo. *Viaggio Germanico, primo quaderno delle lettere Brandenburghesi*, Berlin, 1785, 8vo. A second series of these letters afterwards appeared. *La Sibilla Teutonica*, Berlin, 1786. Reprinted in the fourth volume of the *Revolutions of Literature*. *Reponse à la question: Que doit on à l'Espagne?* Berlin, 1786. This tract was translated into Spanish, and was also printed at the end of the later editions of the *Vicende*. *Lettres Critiques*, a supplement to the preceding, 1786, 8vo. *Apologie de Frederic II. sur la preference que la Roi parut donner à la Litterature Francaise*. Dessau, 1787, 8vo. *Discours sur les Progres de la Litterature dans le nord de l'Allemagne*, Berlin, 1788. *Essai sur la Vie et le Regne de Frederic II.* Berlin, 1788, 8vo. *La Prusse Litteraire sous Frederic II.* &c. Berlin, 1790-91, 3 vols. 8vo. This work may be considered as a supplement to the life of Frederic. *Guide Litteraire*, 1790-91, 8vo. *The Russiad;* a poem, 1799. It was translated into French by M. André, in 1809, under the title of *Pierre le Grand*. *The History of Piedmont, and of the other States of the King of Sardinia;* translated into German by M. Frederic Strass, from the Italian manuscript of Denina, Berlin, 1800-1805, 3 vols. 8vo. In this history, the narrative is brought down to the recovery of Turin, under the reign of Victor Amadeus II. *Revoluzioni della Germania*, Florence, 1804, 8 vols. 8vo. *La Clef des Langues, ou Observations sur l'origine et la Formation de princip. Langues qu'on parle et qu'on ecrit en Europe*, Berlin, 1804, 3 vols. 8vo. *Tableau Historique, Statistique, et Morale de la haute Italie*, &c. Paris, 1805, 8vo. *Essais sur les traces anciennes du caractère des Italiens modernes*, &c. 1807, 8vo. *Discorso istorico sopra l'origine della gerarchia e de' concordati frà la podesta Ecclesiastica e la Secolare*, 1808, 8vo. This work was afterwards suppressed. In the *Melanges de Philosophie, d'Histoire, de Morale, et de Litterature*, No. 49. there is a long and severe article upon the *Discorso Istorico*. *Istoria della Italia occidentale*, 1809, 6 vols. 8vo. Besides these works Denina wrote some other tracts, which were inserted in various journals.

There is a biographical account of Denina in the *Magazin Encyclopedique* for January 1814, by M. Barbier. See also the *Biog. Universelle*. (H.)

DENIS (MICHAEL), a German author of considerable eminence in poetry and general literature, was born on the 27th September 1729 at Scharding, a Bavarian town on the Inn. He was educated by the Jesuits, and made such rapid progress in the study of the sciences, that he was employed by the society in the instruction of youth, and as a preacher in several provinces of Austria. In the year 1759 he was appointed one of the teachers of the Theresian Academy at Vienna, where he gave instructions in the *belles lettres*, and in literary history, and afterwards became keeper of the Garellian Library. In 1779 Maria Theresa conferred upon him the honorary title of councillor; and upon the dissolution of the Theresian Academy, in 1784, the Emperor Joseph appointed him second keeper of the imperial library. In the year 1791 he became first Librarian, and received the title of Aulic Councillor. He died on the 29th September 1800, at the age of 71.

Denis was among the first who promoted the study of the German language and literature, and contributed to the refinement of taste, in the Catholic portion of the empire. He translated the *Poems* of Ossian into German hexameters; and wrote original pieces, both in Latin and German. He was well versed in classical literature; but in his own compositions he preferred the northern mythology, and professed to imitate the style of the ancient bards. The best of his poetical productions are to be found in the collection published under the title of *Songs of Sined the Bard;* in which he celebrates the great personages and events of his own times, in a bold metaphorical style, and a spirited flow of lyrical versification.

We are indebted to Denis for several important contributions to the science of Bibliography, as will be seen from the following list of his principal works:

Poetical Pictures of most of the Military Occurrences in Europe since 1756. Vienna, 1760, 8vo.

Poetical Pictures. &c. since 1760. Ibid. 1761.

Poems of Ossian and Sined. 5 vols. 4to. Vienna, 1784. (The translation of Ossian was first published in 1768; the Songs of Sined in 1772.)

Carmina quaedam. Vienna, 1794.

Introduction to Bibliography and Literary History. Ibid. 1777 78, 4to.

Annalium Typographicorum, V. Cl. Mich. Maittaire Supplementum. Adornavit Mich. Denis, &c. Ibid. 1789, 4to.

The Curiosities of the Imperial Garellian Library at Vienna. Ibid. 1780, 4to.

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DENMARK, a kingdom in the north of Europe, which, though limited in extent, is an interesting object to the political philosopher, from the pacific and enlightened manner in which it has long been governed. It received a severe blow by the cession of Norway in 1814, Swedish Pomerania (subsequently exchanged for Lauenburg and a sum of money) being altogether an inadequate return for that ancient possession. However, Denmark exhibits in its present state a concentrated territory, possessing very considerable means of increasing its resources, both by navigation and inland improvement. Its continental part consists of a long tract of land, beginning in the neighbourhood of Hamburgh, and stretching northward above four degrees of latitude (from $53\frac{1}{2}^0$ to beyond $57\frac{1}{2}^0$) to the extreme point of Jutland; Holstein forming the southern division, Sleswick the central, and Jutland, which is by much the largest, the northern. Adjacent to this mainland tract are the Islands, viz. Funen, of which the capital is Odensee, and the larger island of Zealand, which contains Copenhagen. The smaller islands are Laaland, Falster, Moen, Laugeland, and Femern, along with others of still less importance. The islands, and the portion of continent just mentioned, form the integral part of Denmark, and contain, along with Sauenburg, a surface of about 22,000 square miles. The remote appendages of the monarchy are much more extensive though of infinitely less consequence, consisting of Iceland, the Faroe Isles, and part of Greenland; along with possessions in the East and West Indies.

Aspect, Climate, and Products.

The surface of the Danish territory, particularly of the mainland, is in general level; there are consequently no rivers of magnitude, but a number of smaller streams. The climate is not unlike our own, partaking greatly of the characteristics of a northern region, indented by the sea. The atmosphere is often thick and cloudy, but the extremes of cold, and still less those of heat, are seldom intense, or of long continuance. The moisture of the air affords, as in Britain, a freshness and richness of pasture, which is sought in vain in the interior and southern parts of Europe; hence the superiority of their horses and horned cattle, both of which are much valued, and form a considerable article of export, particularly from Holstein: the annual export of horses exceeds 15,000, the value L. 200,000. Butter and cheese are likewise abundant, and are exported in large quantities. Sheep were not improved with equal success, their wool being short and coarse; they have, however, of late, been considerably ameliorated by an intermixture with merinos.* The agricultural produce consists of oats, barley, beans, peas, and particularly of potatoes: wheat is raised, but not to a great extent. Hops, flax, and hemp, are also objects of cultivation, but in inconsiderable quantities. Gardening is little practised, unless in the island of Amak, the grand store-house for kitchen vegetables for the adjacent metropolis. Madder is good in quality, and considerable in quantity.

The forests of Jutland, formerly so extensive, have now in a great measure disappeared; hence the necessity of importing timber for building, and of resorting to turf for fuel. Of salt, a large quantity is made from brine springs, near Oldesloe; but as this is the only salt work in the kingdom, a great importation of the article takes place annually. Of coals, very few veins have as yet been found.

Population.

There has not been for some time back a complete enumeration of the inhabitants; judging from the returns of 1803 and 1811, we should put down the following as approximate numbers.

Jutland, - - -	400,000
Zealand (including Copenhagen), Funen, and the other Islands, - -	550,000
Sleswick, - - -	300,000
Holstein, - - -	350,000
Iceland, - - -	50,000
Lauenburg, - - -	35,000
Faroe Islands, - - -	5,300
Settlements in the East and West Indies, and in Africa, - - -	100,000

So that since the dismemberment of Norway (the population of which exceeded 900,000), the Danish dominions do not contain above 1,800,000 inhabitants.

National Character.

The Danes are of middling stature and fair complexion, habituated, more than the inhabitants of the South of Europe, to the use of animal food and spirituous liquors. The inhabitants of Holstein, and even of Sleswick, partake a good deal of the German character. Without going into any nice discrimination of manners, it may be remarked in general terms, that the Danes have the habits of a people living in a northern latitude,

* In the days of prejudice, even the privilege of breeding and fattening cattle was vested in the proprietors of land, or in public bodies, to the exclusion of the peasantry; restrictions were also imposed on the export of those of a certain age and quality. All these absurd limitations disappeared in 1788, the year when the government declared that the peasantry should be redeemed from their degrading bondage. This measure, obvious as was its utility, was adopted in a way that implied only a gradual execution. For it was not until the end of the century that all the inhabitants of Denmark were to be considered free,

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and little acquainted, except in the capital, with the improvements of the more polished part of Europe. The peasantry, moreover, are but recently emancipated from a state of feudal subjection. On the other hand, the Danes possess the advantages resulting from the establishment of the Protestant religion, and from a long exemption from the superstition and idleness attendant on the Roman creed: speaking generally, improvement has made a visible progress among them during the last half century.

Government.

The government of Denmark, like that of other Gothic countries, was formerly far from despotic; the succession to the crown was even elective, until the revolution of 1660; a revolution in which monarchy was not only declared hereditary, but absolute, in the most unqualified sense of the word, it being inserted as a fundamental article, that any prerogative not conferred by the act then past, if found to be enjoyed by the king of any other country, was to be tacitly considered as vested in the king of Denmark. This singular change is to be explained, not by supposing, on the part of the nation, an indifference to liberty, but by a resentment of the overbearing conduct of the nobility, and a consciousness of the perpetual uncertainties of an elective government. The court found it thus a matter of no great difficulty to unite the clergy and commons against the aristocracy; and the power of the crown has since continued without any constitutional check. It is tempered, however, in various ways;—by the influence of the reformed faith, the freedom of the press, and the progressive improvement of the nation.

Laws.

In regard to law, there is as yet no general code for the kingdom at large; Sleswick and Holstein preserving their respective usages and institutions, while Jutland and the islands are governed by the code of Christiern V. Jutland is divided into four; the islands into three great bailiwicks.

Revenue, Navy, and Army.

The revenue of Denmark is between L. 1,500,000 and L. 2,000,000 sterling a-year; of this about L. 120,000 arise from the dues at the Sound. The national debt, formerly very inconsiderable, has been increased by the emission of paper. Its amount, from the fluctuating value of this currency, hardly admits of calculation, but may be put down at nearly ten millions sterling. In regard to the army, the peace establishment of regulars was, by a late return, 24 regiments, consisting of nearly as many thousand men. In 1801, before their maritime disasters, the Danish navy consisted of more than 20 sail of the line, fit for service, and well provided with stores; the arrangements of the naval arsenal at Copenhagen being an object of general admiration. But their force is much reduced since 1801, and still more since 1807. The naval establishment in peace is calculated for only 4000 men; but as the number of sea-faring people in the kingdom is great, and nearly 15,000 of them are registered for service, there is no difficulty in manning the royal shipping.

Religion.

The established religion in Denmark is the Lutheran, which was introduced so early as 1536, the church revenue being at that time seized and retained by the crown. At present the nomination of the bishops is vested in the king, and the number of these dignitaries, since the cession of Norway, is only nine; of clergymen the number in Jutland and the islands is 1063; in Sleswick and Holstein 517. The bishops in Denmark have no political character; they inspect the conduct of the subordinate clergy, and confer holy orders, doing, in short, most of what is done by their fellow dignitaries among us, except voting in the legislature. Complete toleration is now enjoyed in Denmark, and considerable progress has been made in diffusing Christianity in Lapland, Greenland, and the East Indies, by a missionary institution long established in Copenhagen.

Manufactures.

In regard to manufacture, the Danes have made no conspicuous progress, confining themselves to their own supply in certain articles, and in others importing from this country and Germany. Linen is said to be imported to the value of half a million sterling: to make that manufacture flourish, it would be necessary to produce more flax at home; the freight on so bulky an article adding materially to the price. Earthen-ware is made in many places, but the export of it is inconsiderable; the porcelain manufacture is carried on for account of the crown. The only considerable works in copper and brass are in Holstein; the cannon foundery at Fridrichswark is very extensive; but of iron founderies there are only four in the kingdom. The number of paper-mills throughout the country was, by a late return, only 22; that of sugar refineries 46. The other branches of manufacturing industry worth noticing are the tanning of leather, the knitting of stockings, the making of hats, and, among the peasantry, the practice of making their own linen.

The Danish government was formerly so unenlightened, in regard to the principles of productive industry, as to imagine that labour of almost any kind must be attended with a profit, without considering whether the raw materials were of home growth, or whether the employment in question was particularly adapted to the country; hence encouragements by public premiums and otherwise, to the manufacture of silk, attended with just as little benefit as the assistance so frequently given to our Spitalfields weavers. It is from the north of Germany, and in particular from Lubeck, Hamburgh, and Bremen, that improvement in the useful arts has made its way into Denmark; the principal workmen in a former age were, and some even at present are, from that quarter.

Commerce.

During the seventeenth century, the Dutch were the general navigators of Europe; and the commerce of Denmark, such as it then was, was carried on in their vessels. The wars at the close of that century, and still more at the beginning of the eighteenth, were adverse to the extension of mercantile enterprise; but after the peace of Stockholm in 1720, Denmark enjoyed a long continuance of tranquillity, and experienced its happy effects in a regular increase of her productive industry. The conflicts of other nations, particularly our American war (from 1775 to 1783), and still more that of the French revolution, called neutrals into new scenes of navigation, and added greatly to the activity of the Danish sea-ports. In the year 1800, the number of Danish merchantmen exceeded 2000; their tonnage 250,000; their sea-

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men 20,000. Next came the rupture with England in the spring 1801, which, however disastrous, was of short duration, and would soon have been forgotten in the commercial prosperity that followed our second war with France, had it not been for our extraordinary attack on Copenhagen in 1807; an attack which was followed by the loss to both parties of all the benefits of a state of peace. Stripped of their colonies, and excluded from distant navigation, the Danes could exert themselves only in annoying our traffic in the Baltic; to it they proved a very formidable enemy, and exhibited a striking example of the impolicy of injuring the feelings and violating the independence even of a small state.

The chief commercial towns are Copenhagen, Altona, and Tonningen; of these the trade of the capital is beyond all comparison the greatest. The Greenland whale-fishery forms a considerable branch of Danish navigation; also the intercourse with the different harbours in the Baltic, from several of which they import timber, flax, iron, and corn. From Norway, Denmark receives wood, iron, and fish; from Iceland, oil, beef, tallow, hides, and wool. The trade with that island was, till lately, in the hands of a company of merchants, and afterwards in those of government; since 1788, this absurdity has been relinquished, and the traffic opened to the public. With the Faroe Isles the intercourse is not yet unrestricted: the articles of import are nearly the same as from Iceland. These are insignificant branches; but the Danes are in habits of extensive intercourse with England, Holland, France, and the shores of the Mediterranean. To the last they convey large quantities of dried fish, and derive a profit from hiring their vessels in the ports of Italy and the Levant, their flag being generally respected by the Barbary corsairs.

Fisheries.

No country is more favourably situated for fisheries than Denmark, whether we look to its extent of coast, or the numerous inlets of the sea. Fishing, of one kind or other, has accordingly formed, almost from time immemorial, a principal branch of occupation; and it is remarkable, that the waters of the Baltic contain so little salt, that fresh water fish are found to thrive in the arms of the sea.

Canals and Roads.

The navigation from the north of Germany to Denmark, around the northern point of Jutland, being always tedious, and sometimes dangerous, gave rise to the idea of uniting the two seas by a canal, communicating with the river Eyder. It was begun in 1777, and finished in the course of seven years, at a great expence. This is the canal of Kiel, which begins near that town, on the side of the Baltic, and extends eastward about twenty-three miles, when it comes in connection with the Eyder. Its least depth of water is ten feet; it admits vessels of 120 tons burden; and of such small shipping, no less than from 2000 to 3000 pass in a year. Tonningen is the port on the east coast, and the length of navigation from there to the Baltic is about 105 miles.

After 1807, when the open war between Denmark and Britain made the passage by the Sound inexpedient, if not impracticable, for our mercantile convoys proceeding up the Baltic, recourse was had by them to the Great Belt, the width of which is no where less than 10 miles, and in most parts much greater. Communication by water is very easy in Denmark, but the roads were long neglected; of late, however, considerable improvements have taken place, particularly in Zealand. They were much wanted for mercantile purposes, as well as for travelling; periodical fairs being here, as in other parts of the continent, the grand occasions for the sale of merchandise.

Colonial Settlements.

In point of colonies, the Danes, if they have not settlements of first rate importance, are sufficiently provided in regard to number; having establishments in Asia, on the coast of Coromandel and the Nicobar islands; in Africa, at Christiansburg, and other places on the coast of Guinea; and, in the West Indies, in the islands of Santa Cruz, St Thomas, and St John.

The three West India islands just mentioned contain above 30,000 negroes. Their trade with Denmark, subjected formerly to restrictions, is now entirely open. Their average produce may be estimated at 30,000 hhds of sugar and 12,000 casks of rum, part of which are sold on the spot, and the rest conveyed to the mother country. This gives employment to 60 or 70 sail of merchantmen. The planters were indebted to Dutch capitalists for the advances that enabled them to bring their lands into cultivation. The amount of this debt (nearly L. 400,000) was taken over soon after 1786 by the crown of Denmark, on the calculation that is was better that the colonists should owe the money to the mother country than to foreigners.

The Danes possess the fort of Christiansburg on the coast of Guinea. They have the credit of being the first European state that abolished the slave trade; their government having published a preparatory edict in 1792, and the traffic having finally ceased in 1803.

In India the Danes have several factories or settlements, of which the chief is Tranquebar, on the coast of Coromandel. Their East India Company was established in 1732, and the charter has since been repeatedly renewed, each time with an extension of the right of the public to participate. Since 1797 vessels may be sent out to Danish settlements by private undertakers without restriction. The trade to China, however, continues, as with us, in the hands of the company. But these distant voyages and consequent long credits are not suited to a country of such limited capital. The Danes have been introduced to them by the effect of war and the value of a neutral flag. These gave them great advantages in acting the part of carriers; but they had no higher character; for a trifling proportion of the articles imported into Copenhagen during war remained in the country. The capital of the Danish East India Company hardly exceeds half a million Sterling.

Language and Literature.

The Danish approaches nearer than any of the Scandinavian dialects to German, but it has much less harshness than that language. It is of late only that it has been cultivated for literary purposes. It now contains some good specimens of composition, although rapid improvement is not to be expected in a country of small extent, and where few individuals possess property enough to give them the command of time.

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The names of the Danish *literati* of the present age are little known in foreign countries, in consequence partly of the local interest of their publications, but more from their language being so little cultivated abroad. The travels of Niebuhr are familiar to most of our readers; and the name of Malthe Brun, a Dane residing at Paris, and deeply skilled in geography, cannot be altogether unknown to them. But Denmark possesses various writers of merit, such as Bartholin, Langebeck, and Schjonning in Scandinavian antiquities; Holberg, Suhm, and Snedorf in history; Boye, Gamborg, and Freschow in moral philosophy. Physic, natural history, and, in particular, botany, are also cultivated here. In poetry, lyrics are the department in which the Danes have been most successful. There are a number of scattered societies of men of letters, but no collective body on the plan of the French Institute. The University of Copenhagen was founded in 1476 with ample funds, but with very defective regulations; the latter are, however, much improved of late. Kiel has a university on a small scale, but of comparatively late erection, and on a better plan. Odensee, the capital of Funen, has a college with four professors. There are nine seminaries for the education of schoolmasters, and the number of village schools, great and small, is computed at no less then 3000.

History.

A sketch of the history of Denmark is given in the *Encyclopædia* down to the beginning of the French Revolution. Since then, the foreign policy of the Danish government has been very simple. It has avoided, as much as possible, to take part in war, and has, on all occasions, held an equal and impartial course between the contending powers. Nothing can be more groundless than the allegations repeatedly brought forward of its disposition to favour the French; neutrality, in the strictest sense, being equally its wish and its policy. Repeated complaints, and occasional detentions of the Danish merchantmen took place on our part, during the war of 1793, without, however, leading to a rupture, until the spring of 1801; when the court of Russia, governed by a madman (Paul I.), and impelled by Bonaparte, prevailed on Denmark and Sweden to join in measures which indicated a disposition to assert the right of conveying enemy's property in neutral bottoms. This alliance was crushed in the outset by our attack on Copenhagen. During our second war with France, Denmark forbore all assertion of these rights, and was admitted by our government to have acted the part of a faithful neutral, even in 1807, when our ministers suddenly adopted the determination of seizing their navy. That singular aggression was defended in parliament, not by charging the Danes with hostile intentions, but by urging their inability to resist the increasing power of France. The measure, however, is deeply to be deplored, both as dishonourable in itself, and as calculated to render our name odious in a country where we should otherwise have found sincere well-wishers and cordial allies. Unhappily the connection into which they were thus forced with France could not be discontinued; and it is to our infraction of their neutrality that they may attribute the subsequent loss of Norway, which had been governed by the same rulers for four centuries, and had become, both from intimate intercourse and popular feeling, an integral part of the monarchy. There was only one moment in which Denmark had a prospect of separating herself from France—this was at the end of 1812, after Bonaparte's forces had perished in Russia. She availed herself of it, and opened a negociation with Britain and Russia, which would in all probability have proceeded to an amicable conclusion, had not these powers, in the strait of the preceding year, come under an engagement to Bernadotte, which implied the cession of Norway to Sweden. This cruel circumstance threw the Danes once more into connection with France. When the battle of Leipsic had confirmed the liberation of Germany, Bernadotte had the power of asserting by force of arms his claim to Norway. He invaded Holstein, and, after several severe conflicts, obliged the Danish court to subscribe to the cession of that valuable part of its dominions, in return for Swedish Pomerania, which was subsequently exchanged with Prussia for a part of the country of Lauenburg, and a pecuniary consideration. On the part of England, all was restored except Heligoland. (D. D.)

Derbyshire.

DERBYSHIRE was, in the time of the Britons, a portion of the district that made up the kingdom of the Coritani. During the government of the Romans, it formed a part of Britannia Prima; and under the Heptarchy, it was included in the kingdom of Mercia. It is seated nearly in the centre of England, and is bounded on the east by the county of Nottingham, and a part of Leicestershire; on the west, it is divided from Staffordshire and Cheshire by the rivers Trent, Dove, and Goyt; on the north, it has Yorkshire and a part of Cheshire; and on the south is Leicestershire Its figure is very irregular, approaching nearest to that of a triangle. The greatest length from south-east to north-west is about 56 miles, and its width from east-north-east to west-south-west 33. It contains 972 square miles, and 622,080 statute acres.

Divisions.

This county is divided into the hundreds of High Peak, Scarsdale, Appletree, Repton, and Gresley, Morelston and Litchurch, and the Wapentake of Wirksworth. It contains 16 market towns, viz. Alfreton, Ashbourne, Ashover, Bakewell, Belper, Buxton, Chapel-en-le-Frith, Chesterfield, Crich, Cromford, Derby, Heanor, Ilkeston, Sideswell, Winster, and Wirksworth. It consists of 117 parishes; is included as an archdeaconry in the diocese of Lichfield and Coventry; and divided into six deaneries, viz. High Peak, Chesterfield, Ashbourne, Castillar, Derby, and Repington. Two members are returned to Parliament from the county, and two from the town of Derby. Derby gives the title of Earl to the noble family of Stanley; Chesterfield, the same to that of Stanhope; and Hartington affords the title of Marquis to his Grace the Duke of Devonshire.

Surface and Soil.

There is no English county that presents such a variety of scenery as Derbyshire. The surface of the southern district is, for the most part, pretty level, containing nothing remarkable in its hills, and consequently little of the picturesque. But the northern part abounds in hill and dale, and the scenery is

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in many places romantic and sublime. The county gradually rises from the south to the town of Wirksworth, and thence to the north, assumes a mountainous appearance, which it continues to possess to its extremity. These elevations are the commencement of that mountainous ridge, which from hence divides the island, extending into Scotland. The highest points in the mountainous tract of Derbyshire are, Ax Edge, about three miles south-west of Buxton; Lord's Seat, near Castleton; and Kinderscout, near the north-western extremity of the county. About the town of Derby, and to the south of it, the country is flat and low. In the hilly districts, some of the vallies are very beautiful, particularly those of Castleton and Glossop; but what constitutes the most picturesque and singular scenery of this county, is the great number and variety of smaller vallies, or dales, with which the limestone district abounds. These may differ in extent, and some particular circumstances, but the general characteristics of them all are precipitous rocks, of very singular and picturesque forms, with mountain streams and rivulets running through the lower parts of the dales, whose sides are generally well wooded. The most celebrated of these are, Matlock-Dale, on the river Derwent; Monsal-Dale, the upper part of which is called Millers-Dale, on the river Wye; Middleton-Dale, Eyam-Dale, and Dove-Dale. In Matlock-Dale is a stupendous rock, called the High-Tor, rising almost perpendicularly from the river, to the height of about 300 feet.

The soils of Derbyshire consist chiefly of clay, loam, sand, and peat, very irregularly intermixed. The southern part, which has been distinguished by the appellation of the fertile district, consists principally of a red loam, on various subsoils, which approaches nearer to marl, clay, loam, sand, grit or gravel, according to the nature of the substratum, or its exposure to the atmosphere. Peat mosses are abundant in the northern part of the county, denominated High Peak. The substrata of most of the southern portion of the county consist of gravel, intermixed with large portions of red marl of very irregular forms; in several parts of which are beds of gypsum of considerable extent. The substrata of the other parts of Derbyshire consist of limestone of various kinds, and toadstone; shale and gritstone; coal and indurated clay resting on each other, in alternate layers.

Derbyshire is a well wooded county; and several of the noblemen's parks afford fine oak of noble appearance. Those of Kedleston Park, the seat of Lord Scarsdale, are supposed to be the largest and oldest in the kingdom, several being thought to be eight hundred years old.

Climate.

The atmosphere and climate of Derbyshire vary very much in different parts. From its northern situation, even the southern part of the county is colder, and more frequently visited with rain, than many of the more central counties. In summer, cold and thick fogs are frequently seen hanging over the rivers, and surrounding the bases of the hills; and hoar frosts are not unfrequent in the months of June and July. Owing to the great elevation of the northern parts, some kinds of grain will not grow at all in the Peak; and even that which is sown in the more sheltered places, is seldom cut till late in the year. The winters are, in general, very severe; and the mountains attracting the clouds in their passage over them, cause this region to be distinguished from the others, by the greater quantity of rain which falls upon it.

Rivers.

The chief rivers are, the Trent, the Derwent, the Wye, the Dove, the Erwach, and the Rother. The Trent does not intersect the county, but forms the boundary between it and Staffordshire on the south. The Derwent rises at the northern extremity of the county; its whole length is forty miles. It was formerly navigable from Wylne-Ferry up to Derby, but the navigation was given up when the Derby canal was completed in 1795. The Wye has its origin a little to the north of Buxton, and falls into the Derwent near Rowsley. The Dove, which has its source in the High Peak, a few miles to the south of Buxton, is for many miles the boundary between Derbyshire and Staffordshire; it falls into the Derwent near Newton-Solney. The Wye and the Dove are celebrated for their trout and grayling fishing. The river Rother rises near Padley, and, after running by Chesterfield, enters Yorkshire, near Killamarch. The Erwach flows from the skirts of Sherwood-forest in Nottinghamshire, and falls into the Trent near Long Eaton. The lesser rivers are, the Amber, Barbrook, Burbage, Ecclesburn, Goyt, Lathkill, Maese, and the Morledge.

Canals.

Derbyshire has several canals intersecting it in different directions. The Trent and Mersey, or Grand Trunk Canal, communicating between Liverpool and London, and also with Bristol and Hull, was begun in 1766, by the celebrated Brindley, a native of the county, and completed in 1777, under his able successors, Smeaton and Rennie. It passes through Derbyshire, from Burton to its termination at Wilden Ferry, following the course of the Trent. The Chesterfield Canal was begun 1771 by Brindley, and completed by his brother-in-law, Mr Henshall, in 1776. It enters the county at Killamarch, and terminates at Chesterfield. The Langley Bridge, or Erwach Canal, begun in 1777 by Mr Jessop, commences in the Trent navigation, near Sawley, and terminates at Langley Mill. It runs parallel to the little river Erwach, and opens into the Cromford Canal. Peak Forest Canal was commenced in 1794, and finished in 1800. It proceeds from the Ashton-under-Line Canal, near Dukinfield Bridge, and terminates at Chapel Milton, Derbyshire. The Cromford Canal was begun in 1789. Its line is wholly in Derbyshire, commencing at Langley Mill, where the Erwach terminates, and ending at Cromford. It was completed in 1794 by Mr Jessop. Ashby-de-la-Zouch Canal, begun 1793, but not finished until 1805, is connected with the southern part of Derbyshire; its line passing by Willesley and Measham. The line of the Derby Canal is entirely in this county; commencing in the Trent and Mersey Canal, north of Swarkstone, passing by Derby, with a branch to Little Eaton, and terminating in the Erwach Canal, half a mile south of Sandiacre. The

rbyshire. Nutbrook Canal was made in 1793. It commences in the Erwach Canal, and, after running four miles and a half, finishes at Shipley Wharf.

tals and nerals. This county is celebrated for its abundance of metals and minerals. They are various and plentiful particularly in the limestone strata. Lead ore is found in several forms; but most commonly in galena, or sulphuret of lead. That species called slickenside, having a smooth glossy surface, is found in the Odin and Castleton Mines. The portion of silver united to the Derbyshire lead, is not sufficient to be worth while separating it. A carbonate of lead sometimes occurs. Calamine, or native oxide of zinc, is found at Castleton, Cromford, Bonsall, and Wirksworth. It occurs in various colours, and different qualities; sometimes in nodules, in the form of grapes, and in the ochreous state. Blende, or black-jack, another ore of zinc, is also got. Copper has been found in small quantities only. Pieces considerable in size, detached from any vein, have frequently been met with at Matlock and Bonsall; and a slender vein has been discovered between Tideswell and Buxton.

Iron ore is found, in very great abundance, in all those tracts of the country where coal has been discovered. It lies at different depths; and frequently, from the great dip of the strata, appears on the surface of the ground. The beds of ore are from two to twelve inches thick, producing, generally, that of the argillaceous kind; but the calcareous, or sparry iron ores, of a fine brownish red colour, sometimes bright yellow, scaly, dirty brown, are found in amorphous masses near the surface, and filling insulated places. The principal founderies and forges are, Butterley, Codnor, Morley Park, Wingerworth, Chesterfield, Riddings, and Stavely.

The ore of manganese appears in various forms. The ores of arsenic and antimony appear in small quantities, united with lead ore, quartz crystals, various crystals of calcareous spar, and of fluor, or fluate of lime, gypsum, selenite, barytes, here called cauk. The most beautiful among the fossils of this county is that admired fluor, known by the name of Blue John, or Derbyshire spar, found in the fissures of the limestone, in the neighbourhood of Castleton. This substance, when polished, exhibits an infinite variety of blue, purple, red, and yellow shades: its being transparent shows the colours to greater advantage. Petroleum, or rock oil, is found in the black marble at Ashford. Elastic bitumen, a substance peculiar to this county, resembling in appearance the common Indian rubber, is found in the cavities of the Odin mine.

Coal is very plentiful, abounding in large fields in several districts. It is of different degrees of hardness; comes out of the pit in long stratified pieces of shining fracture; burns with a brilliant flame and crackling noise, and leaves a reddish white ash.

The limestone of this county is of various colours, white, grey, yellow, blue, and black, and of various qualities; some being soft, and some being sufficiently hard to be polished into beautiful marble. Fine freestone, toadstone, shale, clunch, stalactitical concretions, and fuller's earth, are found in different parts.

Impressions of leaves and plants, a great variety of coralline bodies, fossil shells, and even a small alligator, have been found imbedded in the limestone of this county. Derbyshire.

The warm mineral and other springs have long been celebrated. The principal are those of Buxton and Matlock. The heat of the Buxton water is 82°, never varying on account of the temperature of the atmosphere. The water is remarkably pure, being very slightly impregnated with saline particles. It is used both for bathing and drinking, and is chiefly recommended for gout, rheumatism, derangement of the biliary and digestive organs, and diseases of the urinary passages, for all of which it is of considerable efficacy. There are several public and private baths, both for ladies and gentlemen, and one open *gratis* to the poor. It appears from several remains discovered at different times, that these waters were known to the Romans; and, from their time to the present, they have been resorted to by invalids. Warm Springs.

Matlock water is not so warm as the Buxton, the thermometer seldom rising to more than 68° of Fahrenheit. The springs issue from between fifteen and thirty yards above the level of the river: higher or lower the springs are cold, differing in nothing from common water. The water is very pure, and less impregnated with mineral substances than that of Buxton. There are several baths at Matlock, which are much resorted to.

There is a tepid chalybeate spring at Bakewell, the temperature of which is about 59 degrees. It is tonic, and recommended for indigestion, debility, and chronic rheumatism. Here is one bath. There is also, at this place, a spring, which has been found to contain, in 60 quarts, 13 cubic inches of sulphurated hydrogen. The tepid spring at Stony-Middleton much resembles that of Matlock, but is not so warm, being only 63 degrees. There are several other tepid springs in the county. Among the sulphureous springs, that of Kedleston is the strongest. It is like the Harrowgate water; and is used externally for most cutaneous diseases, particularly for those of an ulcerous nature; it is taken internally as an antiscorbutic and diuretic. There are cold and warm-baths. Other sulphureous springs are found in many districts. The most celebrated chalybeate water is at Quarndon, two miles from Derby, which is a good deal frequented.

Among the wonders of Derbyshire, all authors mention the intermitting spring at Barmoor near Tideswell. It is generally called the Ebbing and Flowing well: but the intermission is not regular; for, in dry seasons, the ebbing and flowing ceases for several weeks; and in wet weather it often ebbs and flows every ten minutes.

The south and south-east parts of this county are the best cultivated; for great quantities of excellent wheat and barley are grown there. The arable lands in the northern parts are chiefly cultivated for oats, of which grain there is a great consumption; oaten bread, leavened, being the principal food of the lower classes. The dairy country is around Ashbourne and the south-western side of the county, whence not less than 2000 tons of cheese are annually exported. In the neighbourhood of Chesterfield there are about 80 acres of land employed in the growth of chamo- Cultivation.

Derbyshire. mile. This useful plant was introduced into the county about 1740; and it produces from three to six cwt. *per* acre, and is chiefly consumed at home and in America. Valerian and elecampane are cultivated in Ashover and North Wingfield, in small quantities.

The breed of cows in this county has been very much improved of late years. They are, in general, horned, large, and handsome; yielding, upon an average, ten quarts of milk a-day. They are, most commonly, speckled, with large well-turned horns; though of late, the short-horned Lancashire breed has been introduced. Nature seems to have adapted the horses in Derbyshire to the different regions in which she designed them to labour. In the northern districts the breed is small, of light and slender make; in the southern parts they are in general of a strong and heavy kind; and in the stables of the country gentlemen, this beautiful animal may be found in the perfection of its symmetry. The sheep also vary in size; those that are bred on the borders of Leicestershire differ but little in weight from that county breed; but they gradually diminish in size as we proceed northwards, till they get as small as any in the kingdom. The parks in the county are well stocked with fallow-deer.

Manufactures. The woollen manufactories, for which this county was formerly celebrated, are now confined to the worsted-spinning at Derby, Melbourne, and Tideswell; and to the weaving a few blankets at Chesterfield. The first silk-mill established in this kingdom was introduced into Derby in the beginning of the last century; the improved machinery of which was brought from Italy by the celebrated John Lombe. This mill is still worked with the original machinery; but great improvements have been made of late years in the construction of the spinning apparatus; and the facility attained in working the several articles of silk manufacture, has contributed to the extension of this branch of business in a very eminent degree. The manufacture of stockings was introduced into Derbyshire about 1717; and this acquired additional celebrity by the ingenious discovery of Strutt, who introduced a machine for making ribbed stockings about the year 1755.

The manufacture of cotton was introduced in the year 1771, when Sir Richard Arkwright, the inventor, established one of the first cotton-mills on the improved principles; and, in 1773, he, in conjunction with Mr Jedediah Strutt and Mr Need, made at Derby the first successful attempt to establish the manufacture of calicoes in this kingdom. This county, therefore, is the cradle of the most important branches of the cotton trade; and, at the present moment, an immense capital is employed in the business, which is carried on to a great extent.

There are in several places manufactures of linen; and flax-spinning is carried on in others, but upon a small scale. White and red-lead works; various manufactures connected with the iron-trade; marble and spar works; a long established and celebrated porcelain manufactory; and grindstone mills are found in different parts of the county.

Singular Customs. Among the singular customs of Derbyshire may be mentioned that of rush-bearing; a ceremony of strewing the churches on a certain day with rushes. It usually takes place on the anniversary of the dedication of the church, or on midsummer eve. The ancient custom of hanging up in the churches garlands of roses, with a pair of gloves cut out of white paper, which had been carried before the corpses of unmarried women at their funerals, still prevails in many parishes of the Peak. The country wakes are generally observed here, on the Sunday following the day of the dedication of the church or chapel, or the day of the saint to whom it is dedicated.

Antiquities. The British antiquities of this county are druidical circles, tumuli of earth and stones, rocking-stones, rock-basins, and some rude military works in the uncultivated parts of the county. The Roman remains deserving of notice are, the altar preserved in Haddon-Hall; the inscribed pigs of lead now in the British Museum; and the silver plate found in Risley Park. Several Roman roads, the remains of which are still visible, passed through the county; and many stations of consequence may be easily traced.

The ecclesiastical edifices of this county exhibit the taste of different ages. Of the Saxon period is the Crypt under Repton Church, which is supposed to be the remains of the conventual church, destroyed by the Danes in the year 874. Melbourne church is a very perfect specimen of the massy style of architecture which prevailed in the eleventh century. The desecrated church of Steetly exhibits a very complete specimen of the latter and more enriched style of Saxon architecture on a small scale. Other and numerous remains of Saxon architecture are to be found in this county.

Specimens of the early Gothic style are not frequent; and those of the fifteenth and sixteenth century are inconsiderable, except the tower of All-Saints at Derby, which has been generally and deservedly admired: it is about 150 feet high, and richly ornamented with Gothic tracing.

The only monastic buildings in this county, of which any remains at present exist, are Dale-Abbey, the arch of the east window of which still stands; Beauchief-Abbey, now used as a church; part of the original Saxon monastery of Repton, and an ancient brick tower, part of the prior's lodging.

The ancient castles of Derbyshire, whose ruins now remain, are those of Castleton, Codnor, Horsley, and Melbourne. Castleton was, most probably, erected by William Peverell, to whom the manor was given by William the Conqueror. Connor was the ancient seat of the Grey family. Horsley was built in the beginning of the thirteenth century, by Ferrers, Earl of Derby, and Melbourne existed as early as the time of Edward the Third.

The most remarkable mansion-house in this county, in point of antiquity, is Haddon-Hall, belonging to the Duke of Rutland. It has been erected at various times, but no part later than the middle of the sixteenth century. Hardwick Hall, belonging to the Duke of Devonshire, is another pile of the above description, exhibiting a complete specimen of the domestic architecture, which prevailed among the upper ranks, during the reign of Queen Elizabeth. Balborough Hall is another handsome mansion of the sixteenth century. The manor-house of

Derbyshire || Devonshire.

South-Wingfield, a very spendid and spacious edifice, erected by Lord Cromwell, in the reign of Henry VI. is now a mere ruin, having been suffered to go to decay, soon after the civil war, in the seventeenth century.

Country Seats.

The noblemen's seats are, Chatsworth, the chief seat, and Hardwicke, the occasional residence, of the Duke of Devonshire. Elvaston, the seat of the Earl of Harrington; Sudbury, of Lord Vernon; Kedleston, the elegant mansion of Lord Scarsdale; Bretby, the seat of the Chesterfield family; Sutton, the seat of the Marquis of Ormond; Doveridge, of Lord Waterpark; and Hassop, of the Earl of Newburgh.

The Baronets' seats are, Ashbourne Hall, of Sir Brooke Boothby; Wingerworth, of Sir Henry Hunloke; Egginton, of Sir Henry Every; Sissington, of Sir H. Fitzherbert; Chaddesden, of Sir R. Wilmot; Osmaston, of Sir R. Wilmot; Foremark, of Sir F. Burdett; and Stretton, of Sir W. C. Browne.

There are several elegant and extensive mansions belonging to the gentry of the county; the principal of which are, Willersley, of R. Arkwright, Esq.; Markeaton, of F. Mundy, Esq.; Longford, E. Coke, Esq.; Radborne, E. S. C. Pole, Esq.; Bridge Hill, of G. B. Strutt, Esq.; Hopton, of P. Gell, Esq.; Shipley, of E. M. Mundy, Esq.; Norton, of S. Shore, Esq.; Alfreton, of H. C. Morewood.

Population.

The population of Derbyshire, 1377, assessed to a poll-tax, was 24,289. In 1789, the inhabitants were supposed to be 124,465. In 1801, they were 161,142. In 1811, 185,487, according to the returns made to Parliament. See Pilkington's, Davies's, and Lyson's *Histories of Derbyshire.* (Y. Y.)

DEVONSHIRE, the British name of which was Dyvnaint, and whose inhabitants were called Dyvnonwyn, or inhabitants of low lands, formed a part of the district included in the appellation of Danmonium. During the dominion of the Romans, it was included in the district called Britannia Prima; by the Saxons it was constituted a part of the kingdom of Wessex.

Boundaries and Extent.

The county of Devon is the second in size of all the English shires, being exceeded by that of York only. On the north and north-west, it is bounded by the Irish channel; on the west by the rivers Tamar, and Marsland-waters; on the south and south-east, it has the British channel; on the east and north-east, it is limited by the counties of Dorset and Somerset. Its figure is very irregular, but something like a trapezium. Its greatest extent from north to south is about 71 miles; and from east to west 72; its circumference being about 287, including about 1,633,280 acres of land; thirty-three hundreds, 394 parishes, and forty market towns.

The county of Devon is in the see of Exeter, and included in the western circuit. The assizes are held at the county town, Exeter. It returns twenty-six members to Parliament, viz.—two for the county, and two for each of the following places: Exeter, Totness, Plymouth, Oakhampton, Barnstable, Plympton, Honiton, Tavistock, Ashburton, Dartmouth, Bere-Alston, and Tiverton.

Surface and Soil.

A county of so great extent as Devonshire must have a diversified and irregular surface. The mountains in the vicinity of Dartmoor rise to 1500 and 1800 feet. On the south and south-east are extensive wastes, whose surfaces are covered with rough masses of detached granite and immense rocks. To the north and north-west are large tracts of swampy ground, and many peat bogs of great depth. But that part called the Vale of Exeter, a district, the area of which is about 200 square miles, consists of some very fine land; and though the soils vary considerably, the most prevalent are a strong red loam, foliated clay, intersected with veins of ironstone, and a mixture of sand and gravel. The district called the South Hams is frequently termed the garden of Devonshire, from its fertility. It is strikingly diversified by bold swells and luxuriant vales, and in many parts towards the north, the scenery is picturesque and romantic. The surface and soil of West Devon are remarkably uniform, the latter of which consists of perished slate-stone, rubble and mud, intermixed with a portion of loamy mould. Here the cultivated lands are all enclosed, and villages and farm-houses are frequent. North Devon, or the country round Biddeforde, Barnstaple, and South Molton, contains much productive land, and is greatly diversified with beautiful scenery.

Climate.

Although the climate of Devonshire varies much in different districts, still from its situation between two seas, its immediate exposure to the south-west winds, as they blow from the ocean, and the elevated summits of the surrounding mountains, it is, upon the whole, much milder than that of the other English counties. The winters are exceedingly mild, and proverbially favourable to the cure of pulmonary complaints. The air is generally dry and warm, and the harvest earlier than in any other parts of the west. On the southern coast, the myrtle flourishes in the open air unsheltered.

Rivers.

The principal rivers of Devonshire are, the Taw, the Torridge, the Dart, the Teign, and the Exe; and the lesser are, the Tavy, the Plym, the Yealme, the Arme, the Aven, the Otter, the Sid, the Axe, and the Lyn. In some of them, particularly the Tamar and Tavy, the salmon-fishing is valuable. The royalty of the Tavy belongs to the Drake family, who have constructed a very large weir across the river, furnished with traps for taking the salmon on their way down after a flood. The Exe salmon is esteemed superior to that of any other river in this country. These streams furnish trout in great plenty; plaise, the torpedo, or electric ray, the opah or king-fish, and the sepia or cuttle fish, are found in and at the mouths of these rivers.

Canals.

The Grand Western Canal connects the south-eastern coast and the Bristol channel. Its length is about 35 miles, traversing partly through this county, and passing the towns of Exeter, Tiverton, Taunton, &c. The Tamar Canal follows the course of the Tamar river, on the southern coast of Devonshire. Its northern end is considerably elevated. Its objects are, the import of coals, lime, and manures, and the export of agricultural products. It commences in the Tamar river, at Morwellham quay, and terminates at Tamarton bridge. Tavistock Canal follows a north-eastern direction for about $4\frac{1}{2}$ miles in this county. It commences where the Tamar Canal finishes, and reaches the town of Tavi-

Devonshire. stock where it ends. Several of the rivers of Devonshire are navigable for considerable distances.

Mineral Waters. The mineral waters are numerous, but inconsiderable. They are all chalybeate; the principal of which are those of Gubb's Well, near Cleave; Bella-Marsh, near King-Steignton; Ilsington, near Totness; Brook, near Tavistock; and Brampton.

Metals and Minerals. The ores of iron, lead, tin, and manganese, are found in considerable quantities in Devonshire; and gold, silver, copper, bismuth, antimony, and cobalt, have been sometimes discovered in small quantities. Ironstone is common in many districts, but it is not of a quality that yields much metal. It is supposed that the inhabitants of this county were in the habit of working the iron, as well as the other metallic mines, before the arrival of the Romans. The lead ore of this county is of many kinds, but principally of a greyish-blue colour. The potters' or tesselated ore is of a shining, rectangular, tabulated structure, always breaking into cubical granules; another kind is of a flaky, smooth, and glossy texture, breaking into ponderous fragments; and a third sort is more closely-grained, fracture sparkling and uneven, and very rich in silver. The tin works were anciently numerous and valuable; but the Cornwall mines being much more productive, they are now nearly abandoned. Manganese was first discovered about fifty years ago. It is found in large, rugged, irregular masses, and contains a great variety of crystallizations.

Native silver has been found in different substances, and in various forms. Cobalt, interspersed with numerous filaments of silver, has been found at Sampford in great abundance. Antimony, of a dark lead colour, full of long shining needle-like striæ, has been discovered at Chudleigh, Hennock, and South Bovey.

The minerals of Devonshire are many. Limestone, of almost every description, is found in different parts of the county. In the eastern parts, it has a good deal the appearance of chalk. In the neighbourhood of South Hams, it is hard, beautifully veined, bears a fine polish, and resembles the Italian marble. In other districts, it is manufactured into black marble, variegated with streaks of white; into a flesh colour, having streaks of brown; into a pale red, blue, and into almost every variety of colours. Gypsum is found, but not in abundance, in the neighbourhood of Plymouth, Salcombe-Regis, and Exeter. Fluor spar is produced in great plenty in the mines of Beer-Ferris.

Among the argillaceous substances of the county are fine pipe clay, found in great abundance at Wear-Gifford; potters' clay in the vale of King-Steignton; and slate of an excellent quality near Slapton sands, and East-Alwington.

The silicious class of this county contains quartz crystals of a small size; flints in great abundance, but particularly in the mountainous tract of Haldon. Freestone of various kinds is dug up in the parishes of Salcombe, Branscombe, and Beer. Whinstone, basalt, and a substance like the Derbyshire loadstone, are found in different parts of the county. Granite is met on Dartmoor, where the range which extends into Cornwall commences.

Coal of various sorts is found in Devonshire. That procured at Bovey-Heathfield, and thence called Bovey coal, is a singular production. Its strata extend about nine miles, in a southern direction, the uppermost of which rises to the surface, and is from 18 inches to 4 feet thick, but increasing in thickness downward, until the lowermost stratum of coal is 16 feet thick. This stratum lies on a bed of clay, under which is a sharp green sand, from which rises water of a vivid green colour, abounding in sulphur and vitriol, and as warm as some of the Bath springs. The exterior parts of this coal, which lie nearest the clay, have a great mixture of earth, and generally of a dark brown colour. The veins which lie nearer the centre are more compact and solid, and in colour and weight are like common pit coal. That stratum called the wood-coal is a vein of sometimes chocolate colour and sometimes of black coal, consisting of a number of laminæ, or thin splinters, which will divide like whalebone, and generally dug out in pieces of three or four feet long. The fire made of this coal is more or less lasting according to the veins from which it is dug. The basis of this coal is supposed to be vast assemblages of trees, that have, at various distant ages, been washed by torrents from the neighbouring hills; and on which, from time to time, intervening beds of clay and sand have been deposited.

Pyrites, in globular balls, of various sizes, are obtained in different parts of the county. The outward coat is of a brown rusty colour, composed of very minute angular crystals; and the inside is a very solid substance of sulphur and iron, not radiated.

Agriculture. A society for the improvement and encouragement of agriculture was established in Devonshire in the year 1791, which has been of considerable service in spreading a knowledge of the most improved modes of practice adopted in other parts of the kingdom. The forest of Dartmoor contains considerable tracks, capable of much improvement; and the land in the vale of Exeter, which is the best in the country, is cultivated with wheat, barley, beans, peas, and some little flax. The pasture lands are chiefly appropriated to supply the dairy; but, in some parts, considerable attention is paid to breeding sheep and cattle. Orchards, and apple trees, in hedges, are common in most of the farms; oats, turnips, and potatoes, also, are cultivated in many districts. In West Devon, two-thirds of the inclosed lands are employed alternately in raising corn, and the grasses; red clover, rye-grass, and sometimes white clover, and trefoil. Irrigation is common: so is also peat-burning. In North Devon, the soil is productive, the orchard grounds are extensive, and the inclosures tolerably large. The farms in Devonshire are held, generally, by a lease of three lives, or for ninety-nine years. As the lives drop, new ones are put in, on payment of an adequate sum. Landed property seems to be more regularly divided in this county than in most others; there being very few large freeholds, and the inhabitants live sociably and independently upon their own moderate-sized tenements. Their principal manures are lime, sea-sand, sea-weed, and dung.

Devonshire. Cider. Besides the productions of Devonshire, which it has in common with other counties, its cider deserves notice. It is traditionally said, that the planting of orchards commenced between 200 and 300 years ago, at Buckland Priory. A great quantity of cider is now manufactured, and it is in general of a good quality, but differing according to the districts in which it is made; that of the neighbourhood of Exeter and the contiguous places being the most esteemed.

Butter, &c. In these parts, also, a considerable quantity of butter is made. The average produce from each cow is about a pound a-day. Cattle and sheep are bred and fattened here in great numbers. The fish which abound in the rivers and on the coast of Devonshire, besides the home consumption, afford considerable exportations to the Bath and London markets. The oyster-beds in the neighbourhood of Lympstone, are said to be a hundred acres in extent.

Cattle. Devonshire cows are celebrated through the island. When in a state of the greatest purity, they are distinguished by a high red colour, without any white spots; by a light dun ring round the eye: by being fine in the bone and clean in the neck: by the horns being of a medium length, bent upwards; by the tail being small and set on very high; by being thin skinned and silky in handling; and by the property of feeding at an early age. The North Devon variety is in high estimation for the fineness of the grain of the meat; and the superiority of the oxen over most other breeds, in possessing more activity, being better calculated for labour, and having more blood. The ox is in perfection about the fifth year of his age, and is much used for team-work. The native horses are small, but hardy, and much accustomed to the pack-saddle. The breed of sheep is various; mostly of the Dorsetshire kind as to weight of carcase and length of wool, but characterized by a great variety of heads; some having horns, some having none, and others having nobs.

Manufactures. Devonshire is not a great manufacturing county; yet at Exeter, the lower orders are chiefly employed in the woollen trade; and serge and kerseys, to the value of L. 600,000 *per annum*, have been exported. About 300 persons are also occupied here in the manufacture of cotton. The Heathcoates, having been driven from Loughborough in Leicestershire, settled in this county, in 1816, and have employed many hands in manufacturing lace. The value of the serge manufactured at Ashburton is computed at upwards of L. 100,000 annually; at Barnstable, baize, silk-stockings, and waistcoating are made; and much coarse brown earthen ware is manufactured at Bideford; and shaloons and felts at South Moulton.

Antiquities. Among the British antiquities of Devonshire are the numerous cairns on the eminence called Halldown-hill; a cromlech at Drew-Steignton; and at a little distance from it a *logan* or rocking-stone; several remains of British houses are scattered over Dartmoor.

The ancient castles, now in ruins, are, Berry-Pomeroy, built by Ralph de la Pomeroy, who came to England with the Conqueror; Compton Castle, Rougement Castle, formerly the seat of the West Saxon kings, in the vicinity of Exeter, and according to tradition, built by Julius Cæsar; the Castle of Oakhampton stood about a mile south-west of the town; Plymton Castle was the residence of Richard de Rivers Earl of Devon, in the reign of Henry I. The same person was also in possession of Tiverton Castle, the ruins of which may still be seen; Totness Castle, which appears to have been erected by Judhael de Totnais, to whom the manor was given by the Conqueror.

The remains of the abbeys and monasteries of Devonshire are those of Buckfastleigh, near Ashburton; Buckland Abbey, on the eastern banks of the river Tay; Dunkeswell, near Collumpton; the Cirstercian Abbey at Axminster, is the property of Lord Petre; Hartland Abbey, which forms a part of the present house of Paul Orchard, Esq.; the ruins of a Priory of Benedictines, at Moodbury; Tor Abbey, forming a portion of the modern seat of G. Cary, Esq

The venerable and magnificent Cathedral of Exeter demands the first notice, among the ancient specimens of ecclesiastical buildings. The variety of styles discovered in this edifice, proves that it was erected at various periods. It is supposed that the part called St Mary's Chapel is the ancient Saxon church, erected prior to the year 868. It is likely that the first considerable cathedral was planned by Bishop Warlewart, before the year 1138. At Bishop's Seighton is a church in the early Saxon style. Teignmouth church is a specimen of the earliest building of the Normans.

Island of Lundy. The island of Lundy belongs to this county. It is rather more than three miles long, about one in breadth, and contains 2000 acres of land, 400 of which only is under cultivation.

Principal Seats. The principal noblemen's and gentlemen's seats are, Ugbrooke, near Chudleigh, the beautiful seat of Lord Clifford; Saltram, of Lord Borrington, the largest mansion in the county; Mount Edgcumbe, of the Earl of the same name; Nutivele, the beautiful seat of Lord Heathfield; Castle Hill, of Lord Fortescue; Clovely-court, of Sir James Hamlyn, Bart.; Bicton, of John Lord Rolle; Powderham Castle, the principal seat of the Courtenay family; Escot House, of Sir John Kennaway, Bart.; Haldon House, of Sir Laurence Palk, Bart.; Werrington, a seat of the Duke of Northumberland.

Population. In the year 1700, the population of Devonshire was 248.200; in 1750 it was 272,200; in 1801, it was 354,400; and in 1811, it amounted to 396,100.

See Polwhele's *History of Devon*; and *Beauties of England and Wales*. (Y. Y.)

DEW.

Dew.

The *Encyclopædia* contains a brief account of the earlier observations and experiments relative to the production of dew. But the subject was left in a very imperfect state, and would now require, indeed, to be entirely re-modelled. The progress of physical science during the last few years has dispelled the difficulties which obscured that interesting part of meteorology, and has at length furnished a most luminous and complete explication of the whole train of dependent phenomena. We had therefore designed to give some extension to the present article, in the view of entering into the accessary details, and of stating the results of new experiments, performed with scrupulous accuracy, and by the help of instruments of a refined construction. But the late season, (1818,) however grateful in other respects, having proved unfavourable to such researches, we must defer our remarks and calculations till we come to treat of HYGROMETRY and METEOROLOGY. We are hence obliged to confine ourselves to a sketch of the various opinions that have prevailed concerning the formation of dew, and a short narrative of the successive discoveries made on the subject, till they finally ripened into a consistent and satisfactory conclusion.

Etymology of the Word.

Dew is the humidity which the air, under certain circumstances, deposits, in the form of minute globules, on the surfaces of the bodies in contact with it. The Greek term δροσος was evidently derived from ὑδωρ, *aqua*, implying simply *watering* or *humifaction*. The Latin name *ros* is of the same descent. Our English word is obviously borrowed from the German *thau*, akin to the verb which signifies to *melt*, and conveying the idea, therefore, in the Shaksperian phraseology, of air "*melting, thawing, and resolving itself into a dew.*" The Swedish term *dag* is no doubt of the same origin, though it likewise denotes low *mist* or floating vapour. It is remarkable that the French language, though certainly not remarkable for its copiousness, has two distinct terms for dew,—*serein*, for the humidity which collects in the evening,—and *rosée*, for what appears accumulated in the morning; the latter being derived from the Latin word *ros*, and the former intimating that *clearness* and *serenity* of the sky which is most conducive to the formation of dew.

When the atmosphere has a temperature below the point of congelation, the *dew* which might adhere to the substances exposed to it, passes into the form of *hoar-frost*. This was called by the Greeks παχνη, from its *hard* or *consolidated* nature. The French term is exactly the same compound as our own, *white frost*—*gelée blanche*. But the German language has a simple and primitive word to denote it, *reif*; which, in the Swedish, has been slightly modified into *rim*, a word likewise adopted by the older English writers, and still retained in the Scottish dialect, or dilated into *rime-frost*, and thence probably corrupted into *raw-frost*.

Ancient notions concerning Dew.

As dew appears to collect only during fine clear nights, when the heavens glow with sparkling constellations, the ancients, in the infancy of science, imagined it to be actually shed from the stars, and, therefore, to partake of a pure and celestial essence. Hence the vulgar notion that *dew falls*, which has prevailed through all ages, and continues to tincture every language.* The mythologists described Dew as the daughter of Jove and of the Moon;† and Plutarch asserts it to be most abundant in the time of full moon. The lunar beams themselves were supposed to contribute some influence, being of a cold nature, and, therefore, possessed of a humifying quality.‡ The moon, it was imagined, performed merely the office of an imperfect mirror, reflecting the softened lustre of the sun without any portion of his heat.

Its abstergent quality.

The dew of heaven has always been regarded as a fluid of the purest and most translucid nature. Hence it was celebrated for that abstergent property which, according to the vulgar persuasion, enables it to remove all spots and stains, and to impart to the skin the bloom and freshness of virgin beauty. Like the elixir of later times, it was conceived to possess the power of extending the duration of human life; and Ammianus Marcellinus ascribes the longevity and robust health of mountaineers, in comparison with the inhabitants of the plains, chiefly to the frequent aspersion of dew on their gelid bodies. Dew was also employed as a most powerful agent, in all their operations, by the alchemists; some of whom pretended that it possessed such a subtle and penetrating efficacy, as to be capable of dissolving gold itself. Following out the same idea, the people of remote antiquity fancied that the external application of dew had some virtue in correcting any disposition to corpulence. The ladies of those days, anxious to preserve their fine forms, procured this celestial wash, by exposing clothes or fleeces of wool to the humifaction of the night. It was likewise imagined, that grasshoppers feed wholly on dew, and owe their lean features perhaps to such spare diet. §

Opinion of Aristotle.

The philosophers of Greece, after genuine knowledge had illumed that interesting region, entertained far juster notions concerning the nature and formation of dew. Aristotle, whose universal genius ranged over both the physical and the intellectual world, studied facts closely, and sought to reason accurately from the phenomena actually observed. In his book *De Mundo*, he defines "dew to be humidity detached in minute particles from the clear chill

* Gesner, Facciolatus, and other lexicographers, blend this idea in their definition of *dew*. ROS—*Humor cœlo defluens noctu, cum sudum est, et omnis aura quiescit; qui si gelu concrescat, est* PRUINA.

† Διος θυγάτηρ ἔρσα τρέφει και σελάνας δίας.

‡ Statius has the expression *rorifera luna*.

§ *Rore aluntur cicadæ.* PLIN. XI. 26. *Dumque thymo pascentur apes, dum rore cicadæ.* VIRG. *Eclog.* V. 77.

atmosphere."* In his treatise of *Meteorology* he states, that "dew is only formed beneath a calm and cloudless sky, but never in windy weather."† He farther subjoins, that it collects in low places, and not on the summits of mountains. Vapour, which, according to him, is only heat combined with water, rises in the atmosphere during the day, but when the cold begins to prevail at night, it again discharges its humidity. This vapour, however, he thinks, can never ascend high above the surface of the earth, both because it must soon lose its buoyant heat, and because, in lofty situations, it would be scattered and dissolved by the agitation of the air. Dew is hence most copious in fine weather, and in low damp situations. A north wind checks its production; but a gentle southern gale, charged with humidity, will occasion a copious deposit. When a more intense cold prevails in the atmosphere, the vapour precipitates its humidity in a congealed form, and the dew passes immediately into hoar-frost. Cold occasions this consolidation. Dew has hence the same relation to hoar-frost that rain bears to snow; the frozen mass of clouds constituting the one, and attenuated low vapour, seized by frost, forming the other. The heat of the sun's rays thus first raises the vapour from below; but, in all its subsequent changes and modifications, the moon and stars, contrary to the earlier and more popular notions, exert no sort of influence.

Opinions among the Romans.

The Aristotelian opinions seem to have given place among the Romans, to the ruder notions which prevailed in remote antiquity respecting its mode of formation. Pliny invariably speaks of dew as *falling* from the heavens,—*cum ros cecidisset*. We might expect, therefore, that the poets would continue in their verses to perpetuate the same idea.

> *Sparsaque cœlesti rore madebit humus.*—Ovid, Fast. I. 312.
>
> *Vitreoque madentia rore,*
> *Tempora noctis eunt.*—Id. Fast. III. 880.
>
> ———*qua prata jacent,*
> *Quæ rorifera mulcens aura*
> *Zephyrus vernas evocat herbas.*—Seneca *Trag.*
>
> *Hinc ubi roriferis terram nox obruit umbris.*
> Lucret. VI. 4. 64.

Virgil marks the cold which always accompanies the formation of dew, and which, when it becomes more intense, converts the lucid globules into spicular shoots of hoar-frost.

> *Cum primum gelidos rores aurora remittit.*—Eclog. VIII. 15.
>
> *Punica roribus nimis et pruinis florem amittit.*—Georg.

Fancies of the Alchemists.

The opinion that dew falls from the sky, maintained its credit during the course of the middle ages. The alchemists even carried this idea so far as to fancy that, since the dew gradually evanishes in the progress of the day under the action of the solar rays, it then merely seeks, by sympathy, to regain its native seat in the highest heavens. Nay, some of those ingenious enthusiasts have not scrupled, in confirmation of their wild hypothesis, broadly to assert, that a few drops of morning dew, being inclosed in an empty egg-shell, which is placed at the foot of a ladder resting against the roof of a house, the shell will become buoyant while the sun shines, and will mount along the ladder till it reaches the very top. The famous Van Helmont, who refined on the notions of the alchemists, considered the lights of heaven as of two distinct kinds,—the one which flows from the sun and rules the day, being intrinsically warm and possessing masculine virtue,—the other, which rules the night, and emanates from the moon and stars, being of a feminine nature and having a cool or refrigerating influence. This cold light, he imagined, produces the purest essence of water, which is stored in the moon, to recruit the waste of the nether world; and he supposed the allegory of Jacob's ladder might represent that perpetual ascent and descent of aqueous matter, by which the revolution of the system is constantly maintained. That the moon's beams are naturally cold, he thought sufficiently established, by the prevailing belief of the common people, who carefully avoid sleeping in the open air, without some screen to protect them from the chilling impressions which are shot down upon the ground.

Baptista Porta asserted that air is actually converted into water from the accession of cold, and thought this transmutation proved by the fact, that, on the approach of severe weather, the windows of an apartment have the inside of the panes of glass covered with moisture. Gaspar Schott, as late nearly as the middle of the seventeenth century, was so much persuaded of the coldness of the moon's rays, that he stoutly appeals to the effects of their concentration in the focus of a reflector. This experiment, however, was made sixty years before and with an opposite result, by the famous Sanctorio, the founder of scientific medicine, and the inventor of the thermometer. He actually employed the air-thermometer for the first time; but this very ingenious inquirer must have been deceived by some extraneous circumstances, when he saw the liquor sink so considerably as he asserts, under the calorific action of the moon's light. The philosophical ideas of Sanctorio were perhaps in some instances too refined for his age, and the vulgar notion concerning the production of dew continued afterwards, for more than an hundred years, to be still generally retained. But the progress of horticulture near the latter part of the seventeenth century, brought out some unexpected facts, which seemed at variance with the popular belief. It was remarked, that a bell-glass being placed in the evening over a plant, was in the morning profusely covered with dew on the inside, though scarcely any moisture appeared to adhere to the external surface. The humidity which formed the minute

* Δροσος εστιν ὑγρον εξ ἀιθριας κατα συστασιν λεπτον.

† Γενεται δε ἄμφω αιθριας τε και ανεμου, ουτε γαρ αναχθησεται μη ουσης αιθριας, ουτε συστηναι δυναιτ᾽ αν ανεμου πνεοντος.—The same observation is repeated by Pliny, *Neque in nube, neque in flatu cadunt rores.*—*Nat. Hist.* XVIII. 29. and in another place, still more explicitly—*Rores neque gelu, neque ardoribus neque ventis, nec nisi serenâ nocte.* Id. II. 70.

Dew.

globules, must therefore have risen from the plant or the ground, and adhered against the glass.

Drosocope.

Such, however, was the very slow advance of sound philosophy, that Perlicius, who proposed what he calls a *Drososcope*, consisting of an oblique balance playing in a soft rack, for indicating the quantity of dew accumulated in the absence of the observer, concludes the discourse which, under the direction of Professor Weidler, he delivered in scholastic form on taking out his degree at Wirtemberg, in 1727, with the general inference, that Dew descends to us from the atmosphere of Jupiter, Venus, the Moon, Mars, and Saturn; but that, though it fails from the air, it by no means originates in this fluid. He had found in the month of August, that 250 grains of dew formed on the surface of a square foot in the country, while only 94, and at other times 76, or even 64 grains were deposited in the town.

Ideas of Gersten.

The first person, however, that appears to have openly rejected the inveterate opinion of the descent of dew was Gersten, another German professor, who made several experiments on the subject, and printed at Giessen, in 1733, an Academical Thesis, in which he advanced the opposite hypothesis. He found that all plants exhale, in various proportions, the moisture which forms the aqueous deposit; and remarked, that plates of copper exposed during the night have only their under surface bedewed. This dissertation led the celebrated Professor Musschenbroek to repeat the same observations at Utrecht. Having obtained similar results, he communicated the main facts to his Parisian correspondent, M. Du Fay, who planned immediately a series of experiments on a large scale. This ingenious philosopher caused two tall ladders to be set up, reclining against each other, in a vacant space, remote from all trees and lofty buildings; and on the 25th of October 1736, at four o'clock in the evening, the weather being clear and calm, he laid panes of glass on the steps at the different heights of 6, 13, 17, 25, and 31 feet above the ground. These he visited at certain intervals during the progress of the night. By five o'clock, a pane close to the ground had its under side completely wet, while its upper side was only slightly dewed. At six o'clock, the pane, six feet above the surface, was covered with dew; and at seven o'clock, the effect had reached the highest pane. During the whole night the dew continued to form; but it appeared always more copious on the lower panes.

Observations of Du Fay.

These facts might be deemed sufficiently conclusive; but M. Du Fay sought likewise to ascertain the relative quantities of moisture deposited at different altitudes. He procured several rectangular bits of green cloth, cut six inches long and four inches broad, and adjusted all to the same weight. These he suspended in horizontal positions at four o'clock in the evening, one of them only half a foot above the ground, and the rest at the heights of 6, 13, and 25 feet. On weighing them next morning, he found that they had respectively imbibed 53, 66, 56, and 54 grains of dew. The subsequent night having proved windy, they gained only 7, 9, 10, and 6 grains. It was evident, therefore, that dew is formed not only sooner, but more copiously near the surface of the ground than at greater elevations.

To determine, still more precisely, the several quantities of moisture imbibed at different heights, M. Du Fay took three linen towels, each $3\frac{1}{2}$ feet long and $2\frac{1}{2}$ feet broad, and having dried them thoroughly in the sun, he stretched them horizontally at 1 foot, and 17, and 28 feet above the ground. After exposure during the whole night, the air being quite clear and calm, the lowest one was found to have gained 3060 grains, the next only 2346, and the highest 2742. There occurs some slight anomaly in this result; but on reducing the greatest effect to English measures, it corresponds almost exactly to a cubic inch of dew for each square foot of the surface. This might appear to be rather a low estimate for the climate of Paris in the autumnal season, since, at the same rate, it would give only a deposit of about $2\frac{1}{2}$ inches during the whole year.

Discovery of Musschenbroek.

In the meantime, Musschenbroek made observations on the humifaction of substances placed above the leaden platform of his observatory at Utrecht. The dew formed in such a situation, he thought, could not have risen from the ground, but must have fallen from the atmosphere. But, pushing these experiments farther, he was conducted to a most curious and interesting discovery. He found that dew forms in very different proportions on different bodies, and that it will scarcely adhere to a surface of polished metal, while it streams profusely over glass or porcelain. Even the colour of the substance appeared, in some instances, to alter the effect. Thus, a piece of red morocco leather acquired, by exposure through the night, twice as much dew as another piece of the same size, whether black or blue. A closer examination, however, convinced him that this modification was not caused by the mere colour itself, but was occasioned by the addition or infusion of the matter employed to produce it.

Extension by Du Fay.

M. Du Fay, on his part, repeated those experiments with the same success. He likewise performed others of a similar description. Electricity was, at this period, in high vogue, and he had distinguished himself in that career. It, therefore, struck M. Du Fay that the disposition of certain bodies to attract or to repel dew, was somehow connected with the distinction into electrics and conductors. In the prosecution of this idea, he sought to compare the humifying action of vitreous with that of resinous substances. He took a tin bason of the same shape and dimensions as one of glass, and having coated it on both sides with forty or fifty applications of a solution of shell-lac in alcohol, he exposed the two vessels during a fine clear night; but the surface of the glass was found to gather twice as much dew as the resinous coating. In the course of his researches, he likewise noticed another curious fact, the explication of which must be referred to a recent discovery. Having selected two large and equal watch-glasses, he set their convex faces horizontally, the one on a porcelain and the other on a silver saucer, and exposed them both, in this position, to the influence of the night-air; when the former was always observed to collect five or six times more dew than the latter. The metallic surface must have, therefore, in some way or other, contributed by its presence to check the precipitation of humidity, though its direct action is confined to a very

narrow limit, since, under a resinous coating of only the hundredth part of an inch in thickness, the effect is precisely the same as with a cake of wax. In confirmation of this remark, having composed a square plate, by cementing at the edge a polished rectangle of brass, six inches long and three inches broad, to a similar piece of glass, he found, on exposing it to the atmosphere at night, the vitreous surface covered as usual with dew, while the metallic one was scarcely at all affected; but, on laying another slip of glass across these plates, the end which rested on the brass remained quite dry, while the other end soon became profusely wetted.

Results.

It seemed to follow from the experiments of Musschenbroek and Du Fay, that, strictly speaking, dew neither falls nor rises, but, according to the doctrine of Aristotle, only separates, under a certain change of circumstances, from the air, and attaches itself to some substances in preference to others. The theory of vapour, proposed afterwards by Le Roy of Montpellier, threw farther light on the subject. Moisture is suspended in the atmosphere by a real chemical solution, in the same manner as nitre and other salts are dissolved in water. The solvent energy is in both cases augmented by the addition of heat. A rise of temperature enables the air to support a larger portion of humidity, while the decrease of it enfeebles the attractive power, and occasions a precipitation in the shape of mist or dew. This perspicuous explication, as we have seen, had been already anticipated, though but vaguely stated, by Aristotle.

A deposition entirely similar to dew or hoar-frost is hence formed, whenever the air becomes suddenly chilled, by touching any surface much colder than itself, and not consisting of polished metal. Thus the walls of long passages, vaults, or massive buildings, generally drip with wet during the early part of the summer, before the external heat has sufficiently penetrated. In like manner, it is observed, that when a severe and long-continued frost is succeeded by a thaw, that the backs of houses are quickly incrusted with shoots of hoary icicles.

The formation of dew is hence easily produced artificially in a close room, without waiting for exposure under a clear nocturnal sky. If a caraffe, filled with water from a spring or well, be carried into a warm apartment, the outside of the glass will become soon covered over with an aqueous deposit, which must increase till the body of water has acquired nearly the temperature of the encircling air, and will afterwards gradually disappear. But if a piece of tin-foil be applied to the bottle, it will remain dry, while the rest of the surface appears humified with dew.

Various Observations of Leslie.

It is a curious fact, that air always begins to deposite its moisture on glass, even before it has reached the point of saturation, or become absolutely damp. This property, and the circumstances connected with it, Mr Leslie discovered, in the year 1798, by help of his hygrometer, which he had already brought nearly to a state of perfection. On exposing wine-glasses at the approach of evening, they were soon covered with dew, while this instrument still indicated several degrees of dryness. The difference was yet greater in summer than in winter. The hygrometer being inclosed within a small glass receiver, placed on a wetted plate likewise of glass, stood, after the whole internal surface had become lined with dew, at 5°, in a very cold room, but at 15°, when the apartment was kept warm.

The general observation is explained by Mr Leslie's researches into the propagation of heat. No adjoining substances can ever come into absolute contact; but air approaches much nearer to the boundary of glass, porcelain, or paper, than to a surface of polished metal. By an extension, therefore, of the principle of capillary action, the suspended aqueous particles, which have a strong adhesion to glass, to which they are brought so close, readily detach themselves from their union with the air. But the same particles being held back from the proximity of a metallic surface to which they have little attraction, are never deposited on it unless the air is actually overloaded with them. The hygrometer will, accordingly, reach the absolute zero, when it is shut up within a case of polished tin.

Mr Leslie afterwards made several occasional observations relative to the production of dew, particularly during a series of clear warm days in the month of May 1801, at Easbury in Dorsetshire, where he placed his instruments both on the lawn and on the balustrade of a tower sixty feet in height. Without entering into details, it may be sufficient here to mention the principal results. The periodical variations, both of the hygrometer and thermometer, were much greater near the surface than at some elevation. On the approach of sunset, the thermometer on the ground sunk rapidly; the hygrometer relapsed to about five degrees, and the dew began to form on the blades of grass. During the night, the thermometer descended still lower, the hygrometer indicated absolute humidity, and the lawn was covered with a profusion of dew. But a little after sunrise, the thermometer again mounted, the hygrometer began to act, and the sheet of moisture gradually exhaled. In the progress of the day, the heat and dryness increased; and, about two o'clock, the thermometer and hygrometer, both of them screened from the direct action of sun, stood generally, the former at 75°, and the latter at 85°. But, on the top of the tower, all those changes were less violent. The thermometer, which at that altitude seldom rose in the course of the day to 70°, or the hygrometer to 65°, indicated, as night again closed, a depression, though very moderate in comparison with what was shown at the surface of the ground. The thermometer stood several degrees higher than below, the hygrometer remained at a dryness of 15° or 20°, and no dew was deposited on the balustrade. But similar differences of effect, although on a smaller scale, were exhibited at very moderate heights. On lifting those instruments in the evening only a foot from the ground, the thermometer would rise a degree or two, and the hygrometer mount from the verge of moisture to perhaps 10°. At an elevation of four feet, those changes were nearly doubled. The dew thus always began, as in Du Fay's experiments, to form at the surface of the earth, and continued to mount upwards with the progress of the night.

Explication of the Phenomena.

It is hence easy to explain the general phenomena of dew. "In fine calm weather, after the rays

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of the declining sun have ceased to warm the surface of the ground, the descent of the higher mass of air gradually chills the undermost stratum, and disposes it to dampness, till their continued intermixture produces a fog, or low cloud. Such fogs are, towards the evening, often observed gathering in narrow vales, or along the course of sluggish rivers, and generally hovering within a few inches of the surface. But in all situations, these watery deposits, either to a greater or a less degree, occur in the same disposition of the atmosphere. The minute suspended globules, attaching themselves to the projecting points of the herbage, form dew in mild weather, or shoot into hoar-frost when cold predominates. They collect most readily on glass, but seem to be repelled by a bright surface of metal."* The unequal heating of the surface during the day thus occasions, on statical principles, a perpetual interchange between the higher and the lower atmosphere, which is prolonged through the night, the warm portions of air still continuing to ascend, and leaving their place to be occupied by the descent of similar cold portions of that fluid. This vertical play is a provision of nature for the attempering the diurnal vicissitudes of climate. "In clear and calm weather, the air is always drier near the surface during the day than at a certain height above the ground, but it becomes damper on the approach of evening, while, at some elevation, it retains a moderate degree of dryness through the whole of the night. If the sky be clouded, less alteration is betrayed in the state of the air, both during the progress of the day and at different distances from the ground; and if wind prevail, the lower strata of the atmosphere, thus agitated and intermingled, will be reduced to a still nearer equality of condition."†

Curious Experiments of B. Prevost.

The descent of chill air caused by superior density, explains the formation of dew in low situations, and its progressive elevation as the cold accumulates. But some farther explication was wanted to reconcile the concluding observations of M. Du Fay. The subject was in consequence resumed by M. Benedict Prevost, who performed a curious set of experiments, described in a Memoir read before the Philosophical Society of Montauban in 1803. The results are certainly perplexing, and would almost seem anomalous. 1. Tin or copper foil, and gold or silver leaf, being applied to plates of glass, and exposed to dew, were observed, as before, to remain generally dry, while the vitreous surface became bathed with moisture. 2. After exposure to the night-air, not only a dry border appeared, extending a little way beyond the film of metal, but the side opposite to that coating continued still dry, though all the rest of the glass was profusely wetted. 3. A piece of glass, being laid above the metallic leaf, destroyed its effect. 4. A rectangular piece of tinfoil being pasted on the inside, at the top of a pane of glass, in a window having a northern exposure, and a similar piece applied at the bottom on the outside; when the dewing began first against the inside, the interior coating appeared wetter than the naked surface, and the portion of this immediately behind the exterior coating seemed always drier than the rest. The facts were exactly reversed, when the dewing commenced on the outside of the window. 5. Opposite to the middle of a rectangular leaf of metal, a similar but smaller piece being applied on the outside of the pane, when the dew began to form within the apartment, the space behind the exterior coating still remained dry. 6. In all cases, whether on the inside or the outside of the pane, on covering the metallic leaf with a piece of glass of the same dimensions, the effect was exactly the same as if no metal had been interposed. 7. Similar appearances were produced by combining gilt paper or quicksilvered glass, the results depending wholly on the nature of the extreme surfaces, according as they consisted of metal, or of glass or paper.

On reviewing these curious facts, M. Prevost was struck with their apparent analogy to the phenomena of electricity. He thought they might all be comprised under a single proposition: *That glass which separates two masses of air of unequal temperatures attracts or repels humidity according as it is armed with metal on the hot or on the cold side.* To account for these very singular yet interesting facts, he proposed a random and strained hypothesis, grounded on some loose notions of chemical affinities. But we need to stop to examine it.

Theoretical Views.

Dr Thomas Young, in his *Lectures on Natural Philosophy*, published in 1806, concludes a short abstract of the experiments of Prevost, with suggesting, that they would derive their explication from Mr Leslie's *Discoveries on Heat*. The anticipation was perfectly just, though the discoveries themselves required then a little farther extension to embrace the whole phenomena. Mr Leslie had carefully investigated the laws which modify the propagation of hot or cold pulses through an aërial medium from a solid or a liquid boundary. But he did not contemplate the pulsation excited at the conterminous surface of two strata of air having different temperatures. It was indeed impossible to devise an experiment in which the opposite layers of fluid could be kept distinct, for the warmer portions of air would seek always to rise, while its colder and denser portions would endeavour to sink downwards, and thus form, by insensible shades, a vertical gradation of temperature. But though the pulsatory action excited at each successive horizontal stratum, might singly escape observation, it seemed probable that the accumulated impressions transmitted from numerous boundaries would become very sensible. Accordingly, in a close heated room, the *pyroscope*, or differential thermometer having one of its balls gilt, which is susceptible of such pulses only, marks, near the floor, perhaps four or five degrees of calorific impression, yet, when lifted higher, it indicates an effect always diminishing in proportion to the proximity of the ceiling. The entire action exerted, or the amount of the intermediate energies, was therefore, as the excess of the temperature of the stratum of air next the ceiling above that of the stratum in which the instrument happened to be placed. Carried out of doors in clear and calm weather, after the sun had withdrawn his beams, it betrayed a much stronger tendency the contrary way, and marked a copious frigorific impression, evi-

* Leslie *on the Relations of Air to Heat and Moisture*, p. 132. † *Ibid.* p. 92.

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dently produced by the coldness which must pervade the upper regions of the atmosphere. But to fit the pyroscope for making observations during the day, it was converted into the *Æthrioscope*, in which the influence of light is neutralized,—a combination of great delicacy, and, therefore, a valuable acquisition to meteorological science.* The application of this new instrument has not only ascertained the existence, but measured the intensity, of the cold pulses which are at all times darted downwards from the successive strata of air, though often partially intercepted by clouds, or more completely obstructed by low fogs. But since the spheroidal cup, which concentrates the various oblique impressions on the upper ball of the æthrioscope, can do little more than double the direct action against a horizontal surface, it may hence be computed, that, in fine bright evenings, those cold pulses rained from the sky are sufficient alone to depress the temperature of the ground, according to the seasons, sometimes eight degrees, but generally about three degrees, by Fahrenheit's scale. The blades of grass, thus chilled from exposure, cool in their turn the damp air which touches them, and cause it to drop its moisture. For the same reason, the naked ball of the æthrioscope, as it is still more cooled, appears much sooner affected, being commonly covered with profuse liquid globules, long before the dew has begun to form on the surface of the ground.

Æthrioscope.

Anomalies explained.

All the difficulties and seeming anomalies of the observations of Du Fay and Prevost now vanish away. The various phenomena proceed chiefly from the cold, induced by exposure under a clear sky; but other causes will often essentially modify the results. 1. The impression received on a plate of polished metal scarcely amounts to the tenth part of what is communicated to a surface of glass, wood, cloth, paper, earth, or grass. 2. When the action continues the same, the corresponding depression of temperature yet depends on the slowness with which the cold is subsequently dispersed. In calm weather, a plate of glass, or a sheet of paper, if covered on both sides with a leaf of metal, will gain or lose heat twice as slow as before; and if coated only on one side, its progress will be a half slower. But high winds greatly assist the dispersion of heat, and often reduce the effects of external impressions to the third or the fourth part of their ordinary measure.

Hence the reason why scarcely any dew is formed in windy weather, though the sky be clear; for the frigorific pulses must then have little efficacy, not cooling the ground perhaps more than one or two degrees. In the last observation of Du Fay, the slip of glass laid across the rectangle, composed of alternate bars of glass and of brass, being greatly chilled by exposure, had by contact communicated its coldness to the matter under it, and thus enabled the metal to assist in the deposition of dew. In Prevost's second experiment, the metallic leaf being scarcely affected by the frigorific impressions, checked by its presence the progress of cold along the vitreous surface, and therefore maintained a dry border all around it. Hence, in his third experiment, a piece of glass covering the metal received the entire impressions, and restored the former effect. The application of a metallic coating against the inside of a pane, must, in the fourth experiment, have augmented by one half the efficacy of the external pulses of cold, and thus made the dew to attach more profusely. For a like reason, while a leaf of metal on the outside of a pane became, in the fifth experiment, slightly dewed, the addition of a smaller metallic against the inside increased the effect, by promoting the accumulation of cold.

Wilson's Observations on Hoar-frost.

The remarkable experiments which the late Dr Patrick Wilson, Professor of Practical Astronomy in the University of Glasgow, performed during the severe frost of January 1780, are easily explained on the same principles. In the declivity of a garden, a thermometer laid, in a clear star light, on the surface of the snow, stood from eight to ten degrees lower than when suspended at the height of a few inches. This excessive cold was evidently not occasioned by evaporation, for, on blowing with bellows against the bulb when it lay on the snow, so far from sinking more, the mercury actually rose two degrees higher than its station in the free air. The intensity was, no doubt, in part owing to the low position of the snow, for a thermometer suspended at a pole projecting from a window 24 feet above the surface, indicated four degrees less cold than below. But, besides, the accumulating action of the descent of cold air, the snow must have been also chilled extremely by the frigorific pulses darted from an azure sky. This inference, though not perceived at the time, or, indeed, likely to have been admitted then as philosophical, is distinctly supported by an experiment of Dr Wilson. Having screened a spot of the garden by a sort of sharp roof formed with two inclined sheets of brown paper, and laid a thermometer under it on the surface of the snow, the instrument soon marked 6 degrees of less cold than before, or than another exposed at only a short distance. But this open screen, since it could not impede the mere descent and influx of cold air, must have intercepted a more powerful frigorific influence.

Dr Wilson afterwards performed other similar experiments, which are detailed in his paper on hoar-frost, drawn up in 1788, and inserted in the first volume of the *Transactions of the Royal Society of Edinburgh*. He made the important remark, that during a fog there was no difference of temperature between the surface of snow and the incumbent air. But he neglected to pursue the consequences, and was disposed, from the various facts which he had observed, to conclude vaguely that hoar-frost is always accompanied by a production of cold.

Six's Observations on Dew.

About the same time Mr Six of Canterbury, the inventor of the self-registering thermometer, employed that very useful instrument in making similar but more extensive observations. He found, in a clear summer evening, his thermometer, when laid on the grass, to sink 5 degrees lower than when suspended freely near the surface. But he had occasion afterwards to remark still greater differences.

* See article CLIMATE, p. 197, &c. of this volume, and also Vol. VIII. p. 465, &c. of the *Transactions of the Royal Society of Edinburgh*.

On a clear and still night in winter, the thermometer which had been supported in the air, fell no fewer than $13\frac{1}{2}$ degrees when placed flat on a meadow. He likewise noticed, as Dr Wilson had done, that thick fogs always impede, and often wholly prevent, the peculiar cooling of the ground.

It seemed, therefore, ascertained, that, in the absence of the sun, the surface of the earth, and especially its projecting herbage, acquire, in calm weather, from the mere aspect of a bright and unclouded sky, a very notable degree of cold. This cold appears likewise connected evidently with the formation of dew. But what is the nature of that relation? Is the coldness contracted by substances on exposure to the nocturnal air, to be considered as the effect or as the cause of their dewing? The former opinion, we have seen, was espoused by Dr Wilson, though sound theory should make us expect, that the deposition of dew, or the conversion of humidity from a gaseous to the liquid state, must, on the contrary, occasion a small extrication of heat. But constant experience shows, that cold bodies, not sheathed with metallic lustre, become always sprinkled with minute aqueous globules, from the contact of damp air. The simplest truths, however, are very seldom the soonest perceived; and the late ingenious and learned Dr Wells has the merit of being the first who distinctly attributed the formation of dew to the previous cold induced on the ground from the aspect of the sky. He had early conceived an opposite idea, but a closer examination of the subject led him to adopt juster views. Being once engaged in the research, he prosecuted his observations with assiduity and ardour for upwards of two years, at a friend's villa on the skirts of London, in spite of his professional avocations, and at the evident risk of his precarious health. The numerous facts thus collected, are detailed in his *Essay on Dew*, which appeared in 1814, and immediately attracted a very considerable share of public notice. This little work, however, does not add much to our stock of accurate information, but it is rendered interesting, by the variety of collateral objects which it embraces, The experiments themselves rarely display address or delicacy; and Dr Wells, without ever employing the hygrometer or the pyroscope, instruments which he could have then easily procured, generally contents himself with stating merely rude approximations. Fortunately, such coarse results were sufficient to support the main principle, for otherwise they would have required much correction. But we must still regret that the worthy author should have frequently trusted to conjectural reasoning, instead of appealing to direct experiment.

Discovery of Dr Wells.

Abstract of his Observations.

The chief observations collected by Dr Wells may be reduced to a narrow compass. The coldness of the objects exposed was always found to *precede* the formation of dew, which continued, in favourable circumstances, to accumulate somewhat progressively during the whole night, so that, from midnight to sunrise, the deposition was even greater than from sunset to midnight. Dew was more abundant in the spring and autumn than at other seasons, and it was always very copious when the atmosphere inclined to humidity,—for instance, in clear nights succeeding to misty mornings, or in clear mornings succeeding to misty nights.

The coldness which bodies contract from exposure must be augmented by every circumstance which retards the communication of heat. Hence loose and spongy materials are mostly affected. Thus, in a clear night, the grass was 12 degrees colder than the garden mould, and $16\frac{1}{2}$ degrees colder than a hard gravel walk. In another bright evening, the surface of snow being 9 degrees colder than the air, a piece of swandown laid on it became still 4 degrees colder. Again, a lock of wool, placed on a small table in the garden, became $9\frac{1}{2}$ degrees colder than the air, while swandown, in the same situation, acquired a coldness of $11\frac{1}{2}$ degrees.

The quantities of dew which attach to different substances appear to follow the proportions of their relative coldness. Parcels of wool, each weighing ten grains, being teased out into flattened balls of $2\frac{1}{2}$ inches diameter, and laid on a grass plot, on a gravel walk, and on fresh garden mould, acquired, during a clear calm night respectively, 16, 9, and 8 grains of humidity. In another favourable night, ten grains of wool laid on the table attracted 16 grains of dew; while another similar parcel, suspended at the same height in the free air, acquired only 10 grains; but the former must have also been much colder than the latter, since its confined situation, unlike the open exposition, would check the dissipation of the frigorific impressions. Hence dew is always denser on grass than on the leaves of shrubs.

Coldness of the Surface not the sole cause of Dew.

But the cooling of substances from exposure, though one great source of dew, is not the only cause of its formation. In low fogs, while the ground is scarcely colder than the incumbent bed of air, the humidity yet settles profusely on all bodies, even on the polished surface of metals. From Six's experiments it appears that, from the height of 200 feet, the temperature of the atmosphere, in fine evenings, decreases regularly about 10 degrees, the colder, and therefore denser portions, being always thrown down to the surface. Hence the reason of the ancient remark, that dew is more copious in low vales than on the tops of hills. But the observations of Dr Wells serve to confirm the general statement. A lock of wool exposed on a table, imbibed, during a clear night, 16 grains of dew, but a similar parcel, placed immediately under the table, and consequently screened from the aspect of the sky, attracted 4 grains. In the latter case, the mere accumulation of cold air below, must have occasioned the aqueous deposition.

It might perhaps have been judged sufficient, if Dr Wells had contented himself with assuming the coldness induced on the ground as merely an experimental fact. At any rate, we cannot help regretting that he should have sought the explication of this primary phenomenon from the very loose, cumbrous and visionary hypothesis of M. Prevost of Geneva, concerning what is gratuitously called *radiant heat*. We are at a loss, indeed, to conceive how a speculation, so repugnant to all the principles of sound philosophy, should, at this time, have procured any favour, unless it proceeds from the blind admiration which the multitude are prone to entertain for whatever lulls the reasoning faculty, and appears cloudy and mysterious. (D.)

DIETETICS.

Dietetics.

In the body of the Work, under the title Materia Medica, is inserted a general view of the subject of Dietetics, and a pretty complete list of alimentary articles. The discoveries made in chemistry since that article was written, as well as the progress of physiology connected with the subject of nutrition, will, however, enable us to give some interesting additions on a subject of great importance to every one, without being obliged to treat it again in a regular system.

The necessity of aliment is explained by a knowledge of the functions of the body, and its selection depends upon the same principles. The living machine, as well as those that are inanimate, wastes in proportion as it is used, and this waste must be supplied. To learn the kind of supply required, the kind of waste and its mode must be ascertained.

General view of the subject.

The human body is of a very compound nature; indeed, it is the most compound of all bodies, as well as the most complicated of all machines. It is composed of solids and fluids, and these again consist of various chemical elements in different states of combination. A great part of the mass of our bodies consists of water, and certain animal substances, to which chemists have given the name of fibrin, albumen, gelatin, mucus, and osmazome. Our bones consist principally of phosphate of lime. Besides these, some other principles enter into the composition of our bodies, though in comparatively small proportion. All the elementary matters, of which these principles consist, are continually discharged by the various excretions, but generally in states of combination different from those in which they existed as a part of our body. By the lungs a great deal of carbon and hydrogen is exhaled in the form of carbonic acid gas and vapour; by the skin carbon and hydrogen are also thrown off in considerable quantity; by urine, in addition to carbon, hydrogen, and oxygen, much azote, phosphorus, and lime, are discharged in the form of urea, and the phosphate of lime; and by the alvine evacuation, not only the indigestible parts of our aliment are expelled, but also carbon, hydrogen, and azote, which formed integrant parts of our bodies, and have fulfilled their functions, in the form of bile, mucus, and intestinal flatus. We, therefore, see that there is a constant waste of carbon, azote, hydrogen, oxygen, phosphorus, and lime going on, which must be replaced. But there are only two sources from which this waste can be repaired,—the atmosphere in which we live, and the aliment which we introduce into our stomach. The atmosphere consists of oxygen and azotic gases, and it is very doubtful whether any part of either be absorbed or converted into a part of our bodies. At least we may assume that, from the air, no part of the materials to supply the waste of the body is derived. These must, therefore, be furnished entirely from the matters introduced into the stomach, and those which are calculated to restore any of the deficient elements or principles alone are alimentary. It is not at all necessary that these elements should be in the same state of combination with the principles whose loss they are to supply. It is sufficient that the elements be there, for it is the very essence of the function of digestion to analyse the alimentary matters, and reunite their elements into other combinations assimilated to our nature. From this view of the subject it would, however, seem that the more nearly the alimentary substances approach to the nature of the substances whose waste they are to supply, the less change upon them is necessary, and their digestion and assimilation will be more easy. Upon these principles, animal substances should be more easily digested than vegetable, and a larger proportion of their elements should be assimilated, while a smaller proportion should be separated to form excrementitious or indigestible compounds. In the same manner, vegetable substances are more digestible, and generate less excrementitious matter than inorganic substances, which furnish only a small proportion of assimilable matter, and which must be separated from combinations totally foreign to our nature.

Besides alimentary substances properly so called, there is another class of substances which do not contribute much to repair the waste of our bodies, and yet perform an essential part in the function of digestion. These are called condiments, and their use is to stimulate the organs of digestion to greater activity, and, in fact, they are all much more sapid than the proper alimentary substances, which are in themselves generally insipid or mawkish.

From the view we have taken of aliments, it will appear that they are furnished by all the kingdoms of nature; the mineral kingdom supplying chiefly water and lime, while the vegetable, in addition to these in smaller quantity, yields much carbon and hydrogen; and the animal kingdom, in addition to a proportion of all the preceding elements, furnishes almost all the azote which enters into our composition. Although this statement be generally true, there are facts which, at first, do not seem to accord with it; and there are some grounds for believing, that living bodies have either the power of changing the elementary nature of bodies, or of analysing these bodies we at present consider as simple, so that one is apparently changed into another. Thus some animals, in the state of nature, live only upon animal substances, and it is easy to conceive how, by a very simple process, the blood and flesh of their prey should become a part of their proper blood and flesh. Their elements, and even the combinations of them, are alike. But there are other animals whose flesh and blood do not differ materially from those of carnivorous animals, and which live almost entirely upon vegetable substances, far removed from animal nature, and containing little if any azote.

This subject has lately engaged the attention of Magendie,* the most distinguished Parisian physiologist of the present day; and his views are the most important lately promulgated upon this point, and throw very great light upon the subject of dietetics. To ascertain the sources from which animals derive the azote which enters into their bodies, he performed some experiments which appear to prove, that azote is an indispensable constituent in the food of animals. For the subjects of his experiments he chose dogs, because, like man, they can be supported by vegetable as well as animal food, and he confined them to the use of pure water, and substances totally devoid of azote. *Sugar*, perfectly pure, was first tried. Of this, and of distilled water, he allowed an unlimited quantity to a small dog, three years old. For the first seven or eight days it seemed to agree very well with this diet. It was lively, active, and eat and drank as usual. In the second week it began to fall off, although its appetite continued very good, and it eat from six to eight ounces of sugar in the course of twenty-four hours. Its alvine excretions were scarce and scanty, while that by urine was abundant. In the third week it became more emaciated, it lost its liveliness, and its appetite began to fail. During this period also, its eyes became affected in a singular and very distressing manner. The emaciation increased every day, its strength failed, and although it continued to eat from three to four ounces of sugar daily, it became so weak that it could neither chew nor swallow, and of course could not move. It died on the thirty-second day of the experiment; and, on opening its body, there was a total absence of fat; the muscles were reduced to one-sixth of their bulk, and the stomach and intestines were much contracted. The gall and urinary bladder were both filled with fluid; but on analysis, the bile and urine resembled those of herbivorous animals. The urine, instead of being acid, as in those which eat flesh, was like that of herbivorous animals, sensibly alkaline, and did not contain a trace of uric acid or the phosphates, while the bile contained the picromel so remarkable in ox gall. The excrements also contained much less azote than usual. This experiment was twice repeated, with nearly the same result.

Olive-oil was next tried with two healthy young dogs, which seemed to agree with them for the first fifteen days, but then produced the same bad effects, and both died on the thirty-first day.

Gum was given to several dogs, and always with the same result.

Butter, an animal substance, but which does not contain azote, was also tried; and although, after the thirty second day, the dog was allowed as much meat as it could eat, it died on the thirty-sixth day, similarly affected.

M. Magendie also killed several dogs, at a proper period, after they had got a full meal of oil, sugar, or gum, to observe the nature of the chyle thus furnished. The chyle of the oil was of a decided milky white, while those of the gum and sugar were transparent, opaline, and more watery. These experiments, in M. Magendie's opinion, render it doubtful whether the oils, fats, gum, and especially sugar, are so nutritive as is generally supposed. But, before we adopt his conclusion, we must remember that whole nations subsist upon food which contains very little, if any azote. The Hindoos live almost entirely upon rice; the peasants of Lombardy upon maize; those of Ireland upon potatoes; the slaves in the West Indies get fat during the cane crop, and the negroes of Senegal during the gum harvest, and herbivorous animals are nourished at all times upon grass. M. Magendie is not ignorant of these facts, but tries to explain them away by doubting the accuracy of some of the relations, and alleging that few vegetables are altogether destitute of azote. He cites, in confirmation of his observations, the experiments of Dr Stark, who injured himself by trying to live on sugar, bread and water; and of M. Clouet, who grew extremely weak upon potatoes and water, and instances the insufficiency of sugar and a little rum to support the crew of a shipwrecked Hamburgh vessel. The legitimate conclusions, from all the facts relating to this subject, seem to be,

1. That animals derive the azote which enters into their composition entirely from their food, and hence, that no animal can live for a considerable time upon food totally destitute of azote.

2. That animals, even those naturally carnivorous, can live a certain time upon food entirely destitute of azote, in consequence of which, the excretions of the naturally carnivorous become altered, and throw off less azote than when fed on animal food, acquiring the properties which these excretions have in animals whose food contains a very small proportion of azote.

3. That vegetable and animal substances, destitute of azote, are highly nutritious, provided, at the same time, azote be supplied from the admixture of some other aliment containing it, though in small proportion.

Upon these principles, alimentary substances may naturally and philosophically be divided into three great classes.

I. Those which contain azote, carbon, hydrogen, and oxygen.

II. Those which contain carbon, hydrogen, and oxygen.

III. Those which contain neither azote nor carbon.

1. *Alimentary Principles which contain Azote, Carbon, Hydrogen, and Oxygen.*

The aliments which contain azote correspond with the animal substances in general, and are calculated to repair the waste of our solids and fluids, without great alteration or effort in the digesting organs. All the immediate principles of this class are not, however, equally digestible, or possessed of

* *Memoire sur les propriétés nutritives des substances qui ne contiennent pas d'azote*, 8vo, Paris, 1816.

the same properties. We shall say a few words of each.

1. *Fibrin* constitutes the great mass of the solid matter of the muscles of animals, especially of those which are old and have dark-coloured dry flesh. It is also a principal constituent of the blood of all animals. There can be no doubt, therefore, that it is pre-eminently nutritious in these its natural forms of combination, but we know of no experiments to ascertain its nourishing powers when used alone. The purest form of fibrin which occurs in common circumstances, is the fibre of flesh which has been long boiled in a great quantity of water, as in the remains of the meat from which beef-tea is made, or of that boiled down for soup. This is generally considered, and is often thrown away, as totally indigestible, and deprived of all its nourishing principles: but this is probably a vulgar error, for animal fibre in this state still contains, as much as ever, all the elementary substances which are necessary for animal food; and the only circumstance which can account for their indigestibility, is their great aggregation, which it is the business of cookery to overcome. Fibrin also forms a large proportion of the substance of some of the internal organs of animals, all of which are nutritious, Pure fibrin is white and opaque when moist, but acquires a dark colour on being dried. It does not become putrid when kept in the air, nor even when immersed in water for a considerable length of time. It contracts and shrinks on the application of heat, and gives out, on being burnt, the smell of burning horn or feathers. It is insoluble in cold water—is corrugated by boiling in water—is insoluble in alcohol, but strong acetic acid swells it considerably, and renders it transparent like cartilage, in which state it may be dissolved, or, at least, diffused through water by long boiling.

Fibrin varies in every species of animal, and in the same animal at different ages, either from a difference in its nature, or from a difference in the matter with which it is combined. In many fishes, and the lower classes of animals in general, it is semi-transparent and colourless. In veal, pork, salmon, chicken, and some other kinds of poultry, it has a pink colour; in beef and mutton it is of a fuller red; and in pigeon and game, both birds and quadrupeds, it is dark coloured. In general, it is more tender in the female than in the male, and in the young animal than in the old.

Albumen is also a principal constituent of animal substances, in which it exists in two states, one uncoagulated and the other coagulated. Of the former, the purest example occurs in the raw white of egg. Cartilage, horn, hair, nails, consist chiefly of the latter. It is also a principal constituent of blood and brain; and it seems to be the chief substance of oysters, mussels, and snails. Uncoagulated albumen is sometimes solid, often glairy, always transparent, and, when fluid, is soluble in water, and its taste is bland, or almost insipid. At 165° Fahrenheit it is converted into a white solid mass, of which we have a familiar example in the white of a hard boiled egg. There can be no doubt that albumen, especially in its uncoagulated state, is highly nutritious, and easily digestible.

The curd of milk may be considered as a variety of albumen, although it possesses some peculiar properties, especially that of being converted into cheese by a particular mode of management.

Gelatin is a third very principal constituent of animal solids, as bones, ligaments, tendons, membranes, skin, muscles, &c., and exists in much larger proportions in the flesh of young than of adult animals. Thus we see the gravy of veal and lamb always gelatinize, while that of beef and mutton does not. The swimming bladder of the several species of sturgeon is gelatin in a state of very great purity, and by boiling it may be extracted pure from the shavings of hartshorn. Its taste is bland, and nearly insipid. It is characterized by its solubility in water being much increased by a boiling temperature, and by the solution, when of a certain strength, gelatinizing or cooling. It is highly nutritious, and supposed to be the most easily digestible of animal matters.

Mucus differs from albumen chiefly in not being coagulated by heat or corrosive sublimate, and from gelatin in not being precipitated by vegetable astringents, nor gelatinizing when its solution is concentrated. It exists nearly pure in saliva, and is a constituent of most of the secretions. There can be no doubt of its easy digestion and nutritious quality.

Of these four principal constituents of animal matter we may remark, that in themselves they are almost insipid; that gelatin exists almost entirely in a solid form, more or less dense; that mucus and albumen exist in every form of aggregation, from perfect fluidity to the density of cartilage; and that fibrin is only fluid in the living blood, but in every other instance is a tough solid; and that gelatin is very soluble in boiling water, and gelatinizes on cooling; that albumen is soluble in cold water, and coagulates at 165°; and that fibrin is not soluble either in cold or hot water. We may also remark, that, although chemists have given very definite characters of each, as if they constituted absolutely distinct species of matter, these characters are taken from certain selected kinds of each, and that, in reality, we find that there is a regular and insensible gradation from mucus, through gelatin and albumen to fibrin, and that, as in the process of animalization, as well as in the progress of life, they pass into each other, and many intermediate states are found which cannot be distinctly referred to any of them.

Osmazome, or animal extractive, differs very much from the preceding principles; chemically, in being soluble in alcohol, and to the senses, in being very savoury or sapid. It is upon this, which seems to admit of considerable varieties, that the flavour of animal food, and of each of its kinds, depends. It exists chiefly in the fibrous organs, or combined with fibrin in the muscles, while the tendons and other gelatinous organs seem to be destitute of it. The flesh of game and old animals also probably contain it in greater quantity than that of young animals abounding in gelatin.

Gluten is the only vegetable substance which contains a notable proportion of azote in its composi-

tion. When separated from other principles it forms a tough, ductile, elastic, and tenacious mass of a grey colour, resembling, when drawn out, thin animal membrane; when dried it is brittle, hard, and slightly transparent like glue. When kept moist it ferments and acquires some of the properties of cheese. Immersed in water it at last putrefies. When burnt or distilled it resembles in its properties horn or feathers. It is soluble in concentrated acetic acid, and by the assistance of heat in muriatic acid, and in the alkalies. It then bears a strong analogy to the animal substances in general, resembling, by different properties, fibrin, albumen, gelatin. It is very generally found, though only in a small proportion, in the vegetable kingdom, in all the farinaceous seeds, in the leaves of cabbages, cresses, &c.; in some fruits, flowers, and roots, and in the green feculum of vegetables in general, but it is particularly abundant in wheat, and imparts to wheat-flour the property of fermenting and making bread. On the nutritious powers of gluten separated from other principles, nothing certain is known; but the superior nutritious powers of wheat-flour over that of all other farinaceous substances, sufficiently proves that, in combination with starch, it is highly nutritive, and in all probability it is the gluten of the green feculum which supplies the azote necessary for the support of the herbivorous animals.

2. *Alimentary Principles which contain Carbon, Hydrogen, and Oxygen.*

Starch is very abundantly diffused through the vegetable kingdom. It exists in great purity in various farinaceous grains, such as rice, barley, maize, and millet; it is combined with gluten in wheat; with saccharine matter in some grains, as oats, and in many leguminous seeds, such as harricot-beans, lentils, vetches, and peas; with viscous mucilage, in rye, potatoes, and Windsor-beans; with fixed oil and mucilage in the emulsive seeds, such as nuts, almonds, cocoa, tamarinds, in linseed, rapeseed, hempseed, poppyseed, and, in general, all those from which an oil can be obtained by expression. Lastly, starch is sometimes united to a poisonous substance. Of this singular union of a nutritious with an injurious principle, the most remarkable instance occurs in the roots of the Jatropha manihot, and of many species of arum, to the former of which the negro slaves of the West Indies are indebted for their cassada bread, and from the latter is prepared the best arrow-root starch. Only one species of grain, the *Lolium temulentum*, is hurtful, but many leguminous seeds are poisonous, of which the most familiar example occurs in the laburnum peas.

Starch is artificially prepared in great purity from various substances. *Starch* is got from wheat and potatoes; *arrow-root* from various species of arum; *cassada-flour* from the manioc root; *salep* from the orchideæ in general; *sago* from the pith of various species of pal -trees; *tapioca* from the bitter and sweet cassava root. In all of these varieties of form, starch furnishes a bland and wholesome nutriment.

Gum or *Mucilage* is also a principal ingredient in the composition of our alimentary vegetables. The distinctive character of gum is its solubility in cold as well as hot water, and its insolubility in alcohol. It is devoid of smell, and to the taste it is bland and agreeable. In Arabia, Senegal, and the East Indies, it is obtained in great quantities from the various species of *Mimosa*, from the bark of which it exudes in great purity; and in hot climates, in general, it is furnished by many trees, especially those which have an astringent bark. In our own country, an example of its production is seen on the bark of the plum and cherry trees. Where it is produced in sufficient quantity, it constitutes a principal article of diet; and the Africans of Senegal are said to live entirely upon it during the gum harvest. Eight ounces of gum are the daily allowance, and furnish sufficient nourishment for each man.

Mucilage is the alimentary principle of many of our esculent vegetables. In some it is united only to green colouring matter, as in the leaves of beet and spinach; with bitter matter, which may be prevented by the process of blanching, as in endive, lettuce, succory, and cardoon, or by using the plant very young, as in asparagus. It exists also in every part of the mallow tribe; in many roots, as scorzonera, salsafy, and Jerusalem artichokes, in the receptacle of the flower of the artichoke. It is combined with an acid in sorrel leaves; with saccharine matter in many fruits, as the fig and date; in roots, as the carrot, parsnip, and beet; and with slight acrimony in the turnip, cabbage leaves, cauliflower and brocoli, and with considerable acrimony in the radish, cress, and mustard. It exists in great quantity, combined with a peculiar nauseous principle, in onions, garlic, shalot, leek, &c.; and, lastly, in small quantity, with much aroma, in those vegetables which are used only for seasoning, as parsley, thyme, &c. In short, it is very generally found throughout the vegetable kingdom, and in every mode of union with other principles.

Sugar, the common properties of which, in a state approaching to purity, are familiar, is also highly nutritious. It is crystallizable, soluble in water both cold and hot, in alcohol and the weak acids, readily undergoing, when dissolved in sufficient water, the vinous and acetous fermentation, but, on the other hand, when concentrated, preserving vegetable substances. Chemically considered, it presents many varieties. It exists in greatest quantity, combined with mucilage, in the juice of the sugar cane, of the maple tree, the manna ash tree, and of beet-root. It seems to be a constant attendant upon the inflorescence of vegetables, for almost every flower furnishes honey to the bee, and is a chief constituent of all the acerb, subacid, and sweet fruits, in combination with vegetable jelly. Sugar is produced, or at least collected, by several insects. To the bee we are indebted for honey, and a species of locust in New Holland covers the trees and ground with a kind of sugar. In all animals a principle having some analogy with sugar exists in the bile, and it is a product of morbid action in the disease called Diabetes.

Oil and fat are also nutritious. They differ most obviously in fluidity, and they coincide in being in-

soluble in water, and in containing a larger proportion of hydrogen than the alimentary matters already spoken of. The oils may be divided into the fluid and concrete, and both are furnished by the vegetable and animal kingdoms. Fluid oil exists in quantity in the emulsive seeds, in some of them combined with prussic acid, as in the bitter almond, and in others with an acrid matter, as in the seeds of the ricinus, but it is obtained in greatest quantity and purity from the olive. The animal fluid oils are all more or less nauseous, as spermaceti oil, seal oil, whale oil, and cod liver oil. The concrete oils are generally furnished by the animal kingdom, and these are often bland and agreeable when fresh, but are apt to become rancid in proportion as they are less solid. Butter is the least consistent, if we except the fat of some birds; then hog's lard, the subcutaneous fat of beef, and the kidney fat of beef and mutton in succession. The only concrete oil obtained from the vegetable kingdom is the butter of cocoa.

3. *Alimentary Principles which do not contain Carbon.*

Water is perhaps the only really alimentary substance which belongs to this class, but it is one of the most essential. It is not only necessary to replace the constant waste of water which is drained off from our bodies, by the secretions, the cuticular discharge, and the vapour of the breath, but is in itself strictly digestible, and capable of supplying either hydrogen or oxygen to the system, as may be required, according to the nature of our other food. When we consider how large a proportion of the whole weight of our bodies consists of water only, and that the fluids require more frequent renewal than the solids, the necessity of water as an aliment cannot be disputed. Some animals, as the rabbit, are supposed to be capable of living a long time or altogether without water; but this is a mere deception, for their vegetable food consists almost entirely of water. On the other hand, Dr Fordyce kept gold fishes six months in distilled water, and thought himself warranted in concluding, that animals could live in water and air alone. Pouteau allowed some of his patients nothing but water for several weeks, without their falling off; and the histories of shipwrecked mariners prove, with how small a portion of solid food man can subsist, provided he has sufficient allowance of water, while without water or a substitute, no quantity of solid food can support man for even a few days.

Earths are, perhaps, not altogether unalimentary. Not to mention the depraved appetite of many young females, and of the dirt-eating negroes of the West Indies, for chalk, cinders, and such substances earth is sought after and devoured by whole nations. The luxurious Capuans paid a considerable tribute to the Neapolitans, for an earth called *Leucogaeum*, which they considered necessary for the preparation of a favourite dish, *Alica*. The Tunguses, according to Laxmann, eat a fine clay with rein-deer's milk Chandler saw the women and children in Samos chewing pieces of steatite as a luxury. La Billardiere saw the same practised in New Caledonia, and found edible earth sold in the market in several villages in Java. Throughout all India lime is used along with the betel leaf. Kepler partook of the butter earth, which is eaten with great relish, spread upon bread, by the millstone quarriers of Thuringia; and, lastly, Humboldt has made us acquainted with the existence of a whole nation of earth eaters, the Ottomacs on the Orinoco.* We might also adduce that bird-fanciers find it necessary to supply birds shut up in cages with sand and earth. All these facts, we are aware, might be explained upon principles different from the digestibility of the earthy substances taken into the stomach, and we have no idea that any earthy substances can supply carbon or azote to the system; but we have absolute proof that earthy matter may enter into the circulation, in the growth and absorption of the bony frame of our body, for which phosphate of lime is as necessary as carbon or azote for our soft solids.

Sea Salt is more obviously necessary than earth. Even in insular and maritime situations it is voluntarily used as a condiment by all, but it is only in inland countries, at a distance from the sea, that its necessity is duly appreciated. Muriate of soda enters into the composition of all our fluids, and is thrown off by many of our secretions; hence its waste must be supplied, and where the vegetables are not naturally impregnated with it, it becomes one of the most indispensable articles of our food.

Alimentary substances, as presented to us by nature or prepared by art, may be considered in various points of view.

Digestibility of different alimentary substances.

They differ in regard to digestibility, or the facility with which they are decomposed by the powers of the stomach, to enter into new combinations fitted to repair the waste of the blood. In this particular, also, they may differ in respect to the length of time, or in regard to the digestive power of the stomach, required for their digestion. Thus the digestion of one substance may be slow, though ultimately complete, even in a weak stomach, and that of another quick enough in a strong stomach, although imperfectly digested by one that is weak. In reference to their digestibility, aliments are commonly described as being light or heavy, but in this respect there is very great difference in regard to different individuals, the same substances being light to one and heavy to another, and *vice versa*.

Mr Astley Cooper made some experiments to ascertain the comparative digestibility of different kinds of raw meat without fat; and the following table exhibits the loss 100 parts of each sustained in the stomach of dogs, which were killed, one, two, three, and four hours, after being fed.

Pork	10	20	98	100
Mutton	9	46	87	94
Beef	0	34	37	75
Veal	4	31	46	69

* *Tableaux de la Nature.* Par A. Humboldt, 2 tomes 12mo, Paris, 1808.

In another experiment, after four hours, the digestibility appeared in the following order: Cheese, mutton, pork, veal, beef. Fat appeared to be also much more digestible than cheese; beef than potatoe, and codfish than beef. Boiled veal was much more digestible than roast; and of different parts of the same kind of food, the digestibility was in the following order: Fat, muscles, skin, cartilage, tendon, and bone.* From the experiments detailed in the inaugural dissertation of Dr Macdonald, *De Ciborum Concoctione*, Edinburgh, 1818, which were made in company with the late Dr Gordon, there appears to be great irregularity in the time necessary for the completion of digestion, so that they scarcely furnish any conclusion as to the comparative digestibility of different substances. Dr Macdonald infers that, of those he tried, butter was the most, and rice the least, digestible in the stomach of the dog. In the experiments which Dr Stark made upon himself, to ascertain the nutritious properties of oily substances, he found that, with a daily allowance of 30 ounces of bread and 3 lb. of water, two ounces of olive oil taken at one meal was so large a quantity as to be disagreeable; three ounces in the day caused some uneasiness in his bowels; and four ounces griped him very much, although he gained weight; but this experiment was not conclusive, as at the time he was suffering under sloughing gums, the effects of a protracted diet of sugar. A diet of four ounces of pure fat, obtained from the subcutaneous fat of beef, made into a pudding, with twenty ounces of flour, and twelve or twenty ounces of water, with the remainder of three pounds of water in drink, was both nourishing and agreeable, but when the fat was increased to six ounces, great part of it passed unassimilated, and his bowels were affected. The same pudding without the suet was not sufficiently nutritious, and did not satisfy his appetite in the same manner. When the pudding was made with butter, although only four ounces were used, he was made very ill by it. Oil of butter agreed very well, and oil of marrow, of all the fats Dr Stark tried, he found to be the mildest in the bowels. His gums having again become purple and swelled, with petechial appearances on his body, while making these experiments, suggested to him the following queries, which seem important to the science of dietetics. "Although at present I take more food than what is absolutely necessary for the support of the body, I remain perfectly well, whereas I have several times suffered considerable inconvenience from committing any excess in the quantity of oils. Is it not evident, that excess in the quantity of oils is more hurtful to the body than excess in any other article of food? and that, of course, we ought to be particularly careful in regulating the quantity and quality of the oils we employ in diet? Is it not probable then, that animal oils, though they nourish and increase the weight of the body, are not of themselves sufficient to prevent a morbid alteration from taking place in the blood and fluids? whilst, on the other hand, the lean of meat, though less nutritious, is of more efficacy in preserving the fluids of the body in a sound state?" †

Difference of aliments in respect of nutrition, taste, &c.

Aliments also differ in regard to the proportional quantity of nourishment they furnish, and, in this point of view, they are said to be strong and weak, or rich and poor. This difference may arise either from the proportional quantity of digestible and indigestible parts in the various kinds of aliment, or from the digestible parts being different in kind, and furnishing a supply of a different kind to the blood. There is even in this respect some opposition between light food and strong food, and it may be generally observed, that food which is most quickly digested, requires the soonest to be repeated, while digestible food, that is only slowly digested, supports the body for a greater length of time.

Aliments also differ in the impression they make on our palate; and it is chiefly in this respect that they are considered by the epicure. This impression proceeds from two distinct qualities in the aliment; the one depending upon their grosser physical properties, and the other upon their finer, recognizable only by the senses of taste and smell. To the former class belong the sensations of solid and fluid, hard and soft, tough and tender, crisp and stringy, hot and cold, greasy, glutinous, gritty, smooth, &c. These are judged of by the tongue and palate, rather as organs of touch than of taste, and are altogether independent of flavour, as capable of affecting the organs of taste and smell. The latter class consists of all the variety of tastes, properly so called—sweet, bitter, sour, salt, alkaline, astringent, aromatic, nauseous, pungent, acrid, spiritous, cooling, &c. and also the want of taste, the vapid or mawkish. Of these, some are almost universally agreeable, and others generally disliked, but much depends upon idiosyncracy, state of health, education, habit of the individual, and upon the degree or quantity of flavour.

Aliments also differ in the impression made upon the stomach; but the sensations arising from this source are more obscure and less varied. Except the sensation of heat, which may arise from caloric, and is transient, or from acrimony or spirit, which is more durable, most of the sensations experienced in the stomach are indications of its mechanical state, or of affections of the appetite. Hence we have the feeling of gratification, from removal of a sense of emptiness, of repletion, distension, cessation of hunger or thirst, satiety, and sickness.

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* *A Treatise on the Nature and Cure of Gout and Rheumatism, including General Considerations on Morbid States of the Digestive Organs; some Remarks on Regimen, and Practical Observations on Gravel.* By Charles Scudamore, M. D. 8vo. London, 1817.

† *The Works of the late William Stark, M. D. consisting of Clinical and Anatomical Observations, with Experiments Dietetical and Statistical, revised and published from his original Manuscripts.* By James Carmichael Smyth, M. D. 4to. London, 1788.

Dietetics.

General observations on Diet.

We should also consider the effect of different kinds of diet, when the body is in a state of health, and different states of disease; but accurate experiments are still wanting, to enable us to give any thing more than fragments of this interesting subject. It is extremely difficult to institute these experiments satisfactorily. They are irksome to the person on whom they are tried; and so many causes tend to interfere with the results, that it is only by frequent repetition that the real effects can be fairly deduced.

Our diet may be either proper, or it may err, and this either in quantity or quality. When the quantity is too small, the body is not nourished, it becomes lean, the fat disappears, and the muscles either get soft and flabby, or shrivelled and dried up, accompanied by loss of strength or stiffness, with predisposition to an actual disease. Errors in regard to the quantity of food are merely relative; so much depends upon circumstances, as individuality of constitution, period of life, state of health, degree of mental and corporeal exertion, habit and temperature. Each person may be said to have a different standard quantity, deviations from which are to be accounted errors. In our army, the rations allowed for each soldier at home are, $\frac{3}{4}$lbs. of meat, boiled so as to afford broth, with $1\frac{1}{2}$d. worth of potatoes and other vegetables, 1lb. of bread, or $1\frac{1}{8}$lb. of oatmeal, and in most cases 1lb of milk or coffee is purchased for his breakfast. On service the rations are 1lb. of meat, $1\frac{1}{2}$lb. of bread, and 1 pint of wine, or $\frac{1}{6}$ pint of spirits.

Mr Buxton states, that the diet allowed to the prisoners in the jails in London varies from fourteen ounces of bread *per* day, and two pounds of meat *per* week, which, he says, is not enough to support life, up to one pound and a half of bread, one pound of potatoes, two pints of hot gruel, and either six ounces of boiled meat, without bone, and after boiling, or a quart of strong broth, mixed with vegetables, *per* day, which is as much more than enough; and Mr Buxton thinks that the meat should be discontinued. A fit prison diet, in his opinion, should consist of one pound and a half of bread, at least one day old, to each prisoner daily, and one pint of good gruel for breakfast; and, upon good behaviour, half a pound of meat on Sundays. *

Some experiments have been made to ascertain the quantity of different kinds of food necessary for the sustenance of individuals. Dr Franklin, when a journeyman printer, lived a fortnight on bread and water, at the rate of 10 lb. of bread a-week. Dr Stark, whose weight was 171 lb. avoirdupois, found that 38 ounces of bread daily were not more than sufficient to satisfy his appetite; 48 ounces were the utmost he could consume in one day; and the greatest quantity he could take at one meal, without uneasiness, was 30 ounces; and, with this diet, he required necessarily 3 lb. of water for drink; for with only 2 lb. he was not satisfied. In another experiment, 30 ounces of bread, and 3 lb. of water, with 6 ounces of boiled beef, sufficed; with 4 ounces of the beef his appetite was not satisfied; with 2 lb. of bread, and 3 lb. of infusion of tea, he found that 1 lb. of cold stewed beef was not more than sufficient; he was not satisfied with 4 ounces of beef to breakfast; but 8 ounces at dinner, and 4 ounces at supper, were rather too much.

Absolute starvation produces diminished excretions, fetid breath, foul skin, and death. The most distressing histories of this dreadful end are recorded in the account of shipwrecks, and of those unfortunate persons who fall into the hands of the Arabs of the desert. Man can sustain the absolute want of food for several days, more or fewer in number according to circumstances; the old better than the young, and the fat, probably, better than the lean. The total want of drink can be borne only a very short time, and its effects are more distressing than those of want of food. They have been strikingly described by Mungo Park and Ali Bey, as experienced in their own persons. The narratives of shipwrecked mariners also prove with how very little food life may be supported for a considerable length of time; and the history of those impostors who pretend to live altogether without food or drink, display this adaptation of the wants of the body to its means of supply in a still more striking manner; for, even after the deception, in such cases as that of Ann Moore, is exposed, it will be found that the quantity of aliment actually taken was incredibly small. †

Captain Woodard has added to his interesting narrative many instances of the power of the human body to resist the effects of severe abstinence. ‡ He himself and his five companions rowed their boat for seven days without any sustenance but a bottle of brandy, and then wandered about the shores of Celebes six more, without any other food than a little water and a few berries. Robert Scotney lived seventy-five days alone in a boat with three pounds and a half of meat, three pounds of flour, two hogsheads of water, some whale oil, and a small quantity of salt. He also used an amazing quantity of tobacco. Six soldiers deserted from St Helena in a boat, on the 10th of June 1799, with twenty-five pounds of bread and about thirteen gallons of water. On the 18th, they reduced their allowance to one ounce of bread and two mouthfuls of water, on which they subsisted till the 26th, when their store was expended. Captain Inglefield, with eleven others, after five days of scanty diet, were obliged to restrict it to a biscuit divided into twelve morsels for breakfast, and the same for dinner, with an ounce or two of water daily. In ten days, a very stout man died, unable to

* *An Inquiry whether Crime or Misery are produced or prevented by our present System of Prison Discipline.* By Thomas Fowell Buxton, M. P 12mo. Edinb. 1818.

† *An Examination of the Imposture of Ann Moore, called the Fasting Woman of Tutbury, illustrated by Remarks on other Cases of Real or Pretended Abstinence.* By Alexander Henderson, M. D. 8vo. London, 1813. *Also* Rev. Legh Richmond, in *Medical and Physical Journal*, by Samuel Fothergill, M. D. and William Royston, 469, Vol. XXIX. 8vo. London, 1813.

‡ *The Narrative of Captain David Woodard and Four Seamen.* 2d edition, 8vo. London, 1805.

swallow, and delirious. Lieutenant Bligh and his crew lived forty-two days upon five days' provisions.

In the tenth volume of Hufeland's *Journal*, M. Gerlach, a Surgeon-Major of the Prussian Army, has related a very remarkable and well authenticated case of voluntary starvation. A recruit, to avoid serving, had cut off the fore-finger of his right-hand. When in hospital for the cure of the wound, dreading the punishment which awaited him, he resolved to starve himself; and on the 2d of August began obstinately to refuse all food or drink, and persisted in this resolution to the 24th August. During these 22 days he had absolutely taken neither food, drink, nor medicine, and had no evacuation from his bowels. He had now become very much emaciated, his belly somewhat distended, he had violent pain in his loins, his thirst was excessive, and his febrile heat burning. His behaviour had also become timid. Having been promised his discharge unpunished, he was now prevailed upon to take some sustenance, but could not, at first, bear even weak soup and lukewarm drinks. Under proper treatment, he continued to mend for eight days, and his strength was returning, when, on the 1st of September, he again refused food and got a wild look. He took a little barley-water every four or five days to the 8th; from that day to the 11th he took a little biscuit with wine; but again from the 11th September to the 9th October, a period of 28 days, he neither took food, drink, nor had any natural evacuation. From the 9th to the 11th he again took a little nourishment, and began to recruit; but, on the 11th, he finally renewed his resolution to starve himself, and persevered until his death, which took place on the 21st November, after a total abstinence of 42 days.

On the other hand, the quantity of nourishment that can be devoured with impunity is often very great. Almost every person in good circumstances eats more than is necessary for supporting his body in a state of health; and many bring their stomachs to require a very excessive allowance as almost necessary. In some individuals an inordinate appetite seems constitutional. Charles Domery, aged 21, six feet three inches high, and well made but thin, when a prisoner of war at Liverpool, consumed in one day 4lbs. of cow's udder, and 10lbs. of beef, both raw, together with 2lbs. of tallow candles, and five bottles of porter; and although allowed the daily rations of ten men, he was not satisfied. * Baron Percy has recorded a still more extraordinary instance, in a soldier of the name of Tarare, who, at the age of 17, of moderate size, rather thin, and weighing only 170lbs., could devour, in the course of twenty-four hours, a leg of beef 24lbs. in weight, and thought nothing of swallowing the dinner prepared for fifteen German boors. † But these men were remarkable, not only for the quantity they consumed, but also for its quality, giving a preference to raw meat, and even living flesh and blood. Domery in one year eat 174 cats, dead and alive; and Tarare was strongly suspected of having devoured an infant, which disappeared mysteriously. Many other histories of the same kind are preserved; and although some of the individuals were men of large stature and great strength, others were of ordinary size. The excess of food may be taken either in the form of too much at one meal, or of too many meals. It is either digested and furnishes an excess of nourishment, or it passes through the canal simply indigested, or it undergoes the fermentation natural to it. An excess of nourishment either produces a great or rapid increase of the size of body generally, or of the fat and abdominal viscera in particular, or by inducing great fulness of blood, produces diseases which sometimes counteract the effects of the plethora. When the excess passes simply indigested, it only occasionally proves hurtful as a mechanical irritation in the bowels, especially when it is of a hard substance, and has sharp angles. When it undergoes its natural fermentation this is either acid or putrid, as the substance is vegetable or animal, or rather as it is destitute of, or contains a notable proportion of azote.

When diet errs in quality, it gives rise to a greater variety of cases. It may either produce a directly hurtful effect upon the constitution, in the manner of a poison or medicine, in its natural state, or after fermenting in the stomach; or it may prove injurious more indirectly by not supplying an element necessary for its healthy condition, or by supplying one in excessive proportion. The poisonous effects of alimentary substances are always occasional, and arise from a peculiarity in the aliment itself, as in the case of poisonous fishes, or in the individual, as in those persons who cannot eat particular kinds of food, which are, to others, wholesome and nutritious. The unpleasant effects of substances undergoing their natural fermentation in the stomach, are much more frequently observed. They occur either from a very strong disposition in the food to ferment, so that the action of a healthy stomach is not able to restrain it, or from excess of the food, so that part of it is left to its natural changes, or from weakness of the stomach, which exerts little action upon it. Fermenting substances are hurtful, by acting as direct poisons, and by distending the stomach; in the non-azotized substances becoming acid and producing flatulencies, in the azotized substances becoming putrid and producing fœtid eructations and flatus. Diet, which errs by supplying one of the elementary constituents of our body in excess, or in not supplying another, does not produce its full effects at once, but gradually changes the condition of the body. When an elementary principle is furnished in excess, it is thrown off by the various excretions; and hence we find, that the urine of omnivorous animals, when confined to animal food, con-

* *Account of a man who lives upon large quantities of raw flesh*, by Dr Johnston; in *Medical and Physical Journal* by Drs Bradley, Beatty, and Nohden, Vol. III. 8vo. London, 1800.

† *Memoire sur la Polyphagie*. See *Journal de Médecine, Chirurgie, et Pharmacie*, par MM. Corvisart, Leroux, et Boyer, Tome IX. 8vo. Paris, An. xiii.

tains more urea, and their perspirations and stools are more fetid; while the urea disappears, and the stools and perspirations lose their fetor, when they are restricted to vegetables. The same observations have been made in regard to man. Also, when the supply of an elementary principle is deficient, it ceases to be thrown off by excretion, even after it has performed its functions in the body, but is reabsorbed, and thus the body, for a time, lives, as it were, upon itself.

The chief varieties of diet, in regard to quality, depend upon their immediate effects, and in this respect, they may be divided into the simply nutritious and the stimulant. All animal flesh seems to be more or less stimulant, and, in general, the more so the darker its colour is; and upon this principle, chiefly, has Dr Darwin founded his classification of aliments; but he has erred in considering them as also more nutritious. Moor-game, pigeon, hare, and venison, are more stimulating, but perhaps not more nutritious than the turkey or barn-door fowl, veal, or lamb. The effect upon the composition of our bodies is the secondary, but most important effect. In this respect, food might be divided into the azotized, hydrogenous, carbonaceous, and oxygenous, or rather into those which supply abundantly azote, hydrogen, carbon, and oxygen. This view is, however, chiefly theoretical, as we are very far from possessing facts enough to establish it completely, or to overturn it, but yet there are some which favour it. We have already noticed Magendie's experiments on substances which do not contain azote, from which he inferred that a certain supply of it was absolutely necessary to the support of animal life. Other facts lead to the same conclusion, especially the effect of restriction to one kind of aliment in the generation and cure of disease.

It is now many years since Dr Rollo * was led by the singular sweetness of diabetic urine, to conclude that, if he deprived the patient of all food which contained sugar or the principles of sugar, he should be able to cure this hitherto untractable disease. He, accordingly, restricted his patients to the use of animal food, especially fat, and absolutely prohibited all vegetables, even bread, and all fermented liquors. The effects were very striking, and some patients were believed to be cured. At least the nature of their urine was completely altered from a morbid to a healthy state. As conducted by others, the same regimen has produced the same effects, but it is so disagreeable to the patients, that they can seldom be prevailed upon to adhere to it; and, unfortunately, notwithstanding the temporary removal of this prominent symptom, the disease generally continues its fatal course. We may, however, notice, that Rollo and others were guided in their choice of regimen by the principle of withholding the elements of sugar, and hence fat formed a chief part of it, and was a principal cause of the disgust it excited; but perhaps it would be better to select a highly azotized diet, in which point of view, the muscular parts of dark fleshed animals, such as game and old mutton, and those kinds of fish, such as skate, which contain much azote in a loose state of combination, should be selected, while wheaten bread, the want of which is so distressing to many, might be allowed, and fat, which contains no azote, should not be prescribed.

Magendie † ascribes the gravel to the superabundance of azote in our food, as the uric acid of which gravel consists is a highly azotized substance, and seems to be produced as a means of throwing off the excessive azote, and among the various causes with which gravel is connected, the most active in its agency is high living, or the use of animal food in excess. A Hanseatic citizen, who kept a good table previous to 1814, was afflicted with the gravel. He emigrated and lived very miserably in England, but his gravel completely left him. He re-established his affairs, and with his fortune his gravel returned. Again he was ruined, and went to France almost destitute, and his gravel disappeared. By industry he finally acquired a competency, and with it his old complaint, for which he then consulted Magendie. A Parisian lady of 60, subject to gravel, read in a journal a short notice of Magendie's experiments, in which it was said, that he had discovered in sugar a cure for the gravel. Without more advice she set about eating sugar, often to the extent of a pound daily, and in effect she removed the gravel, but disordered her stomach so much that she was obliged to resume her usual food, and with it the gravel returned.

The chemical theory of the scurvy is, that it is owing to the want of oxygenous food, and it cannot be denied that this theory has been very ingeniously supported by Dr Trotter, Dr Beddoes, and others. The rapidity with which those afflicted with it recover by the use of recent vegetables, especially the fresh citric acid, shows that it proceeds from an error in diet, but whether from a deficiency of nourishment in general, or from a deficiency of oxygenous aliment, is not quite so clear. When we compare the accounts of the ravages formerly committed by this dreadful disease, even during short voyages, with the almost total immunity which the British fleet has enjoyed since the time of Captain Cook, we have the strongest possible proof of the influence of diet upon the human frame, either as inducing or preventing disease. ‡

Hydrogenous food, such as the excessive indulgence in fat meat, butter, and oil, and still more es-

* *An Account of two Cases of Diabetes Mellitus.* By John Rollo, M. D. 2 vols. 8vo. London, 1747.

† *Recherches Physiologiques et Medicales sur les Causes, les Symptoms, et le Traitement de la Gravelle,* 8vo, Paris, 1818.

‡ *Observations on the Scurvy.* By Thomas Trotter, M. D. 8vo. Lond. 1792. *Observations on the Nature and Cure of Calculus, Sea Scurvy, Consumption, Catarrh and Fever; together with Conjectures upon several other subjects of Physiology and Pathology.* By Thomas Beddoes, M.D. 8vo, London, 1793.

pecially in spirituous liquors, produces a change in the chemical constitution of our bodies; independently of the exhaustion of excitability by excess of stimulus. Bilious diseases, and a tendency to unwholesome fatness, are its most common effects, and it is only in the excessive hydrogenation of the system, that we can find a rational explanation of that very singular phenomenon called the spontaneous combustion of the body. For even admitting that the clothes are accidentally set on fire in these cases, there appears no reason to doubt, that the combustion is continued by the burning of the body itself. Now the greatest number of instances have occurred in old women addicted to the abuse of ardent spirits. *

The effects of oxygenous food, in imparting oxygen to the body, are not so well ascertained. Acids, and the subacid fruits, quench thirst, and are supposed to reduce animal heat; but their more obvious action is to affect the bowels and induce diarrhœa, and, ultimately, to render the body spare and thin. The new chemical pathology led to the exhibition of nitric acid for the cure of syphilis, as mercury was supposed to act by oxygenizing the system; and this acid has since been much employed also, from analogy, in the liver complaint. That the acid has excellent effects as a tonic, seems to be perfectly ascertained. It does not act upon the bowels like the vegetable acids, but there is no proof of its decomposition in the stomach or of its imparting oxygen to the body. The oxygenizing of the system by means of the nitro-muriatic or oxy-muriatic bath, now so fashionable in London, is a mere chimera. Pulmonary consumption was also, at one time, considered as a disease proceeding from superabundant oxygen, and the florid colour of the cheeks was adduced in proof of it.

No observations have yet been made on the effects of aliments containing an unusually large proportion of carbon, nor has any disease been ascribed to the carbonization of the system.

Peculiar species of Regimen called *Training*.

It would extend this article much beyond the space we can allot to it, if we were even hastily to sketch the varieties of diet recommended in disease, and to explain their action; but it will not be superfluous to enter a little into the detail of that kind of regimen which has been found by experience to bring animals and man to the highest possible state of health, at least as measured by the amount of their physical force and their power of continuing its exertions. It is to bring animals to this state that constitutes the business of *trainers*, as they are called. Cocks, greyhounds, race-horses, and men, are much more active and vigorous after being trained than in their ordinary condition. They are, in fact, in a higher state of health; and we are fully convinced, that, by training, many diseases might be removed, and by living according to the same principles, general ill health might be commonly prevented. The public is very much indebted to Sir John Sinclair for having taken the pains to collect the fullest information on this subject. † He was assisted in his inquiries, we have reason to believe, by Mr John Bell, whose attention was directed to the subject by having the professional care of Mr Barclay during his great walking match. From the answers procured to Mr Bell's inquiries, it appears, that the whole secrets of training reduce themselves to principles which every man may practise, and ought to practise, so far as consistent with his business and other duties; and, in particular, we think, that they ought to be studied, thoroughly understood, and enforced by all those to whom, in consequence of accidental circumstances, the care of the health and lives of many individuals are entrusted. We allude, chiefly, to military and naval officers, and the proprietors of large manufactories. In the British navy, the importance of this subject has been long appreciated; and the comparative state of health of our fleets in recent and former times, is as honourable to our naval commanders, as the laurels of victory which encircle their brows. Soldiers are left more to themselves, and their officers have neither the same control nor responsibility; but we think that more might be done in keeping the troops, as well as the military horses, when at home or in garrison, always in a state fit for active service. The evil of not attending to this was severely experienced during the Spanish campaign. The artillery horses sent from Chatham were found to be unfit for the fatigues of service, and good cart-horses were, at last, substituted with great advantage. In garrison, both men and horses are over-fed and under-worked. In manufactories the opposite evils sometimes occur; the workmen, and especially the children, are over-worked and under-fed. This subject has lately occupied the attention of Parliament; and it is connected with some interesting inquiries, which belong properly to the science of political economy. In a medical point of view, the principle to be followed is, that the food and labour bear a just proportion to each other. When the quantity and quality of the food is not limited by its expence, the best possible condition of the individual is attainable, by attending to the principles upon which training is conducted, and which resolve themselves into temperance without abstemiousness, and regular exercise in the open air. Mr Jackson, the lord of the ring, says, that a man properly trained feels himself light and *corky*, as the technical phrase is; and that, during a course of training, the skin always becomes clear, smooth, well-coloured, and elastic; or that cleanness of skin is the best proof of a man being in good condition. Another very striking effect

* *An Essay, Medical, Philosophical, and Chemical, on Drunkenness, and its Effects on the Human Body.* By T. Trotter, M. D. 8vo. London, 1804. *Essai sur les Combustions Humaines produits par une long abus des liqueurs spiritueuses.* Par Pierre-Aimé Lair, 12mo, Paris, 1801.

† The *Code of Health and Longevity*, Vol. II. *Appendix*, No. IV. 8vo. Edinburgh, 1807.

of training is upon the lungs. Trained men can draw a much fuller inspiration, and retain their breath longer than others. But it is not only on the state of bodily health that the good effects of training are conspicuous; for Mr Jackson distinctly, and, we believe, correctly states, that the mental faculties are always improved, the attention is more ready, and the perceptions are more acute. From these observations some valuable hints may be derived by physicians, for the cure of many cutaneous and pulmonary affections, which obstinately resist the power of medicines.

Cookery.

Cookery is strictly a branch of Dietetics, and one of the most important. Only a small part of our food is consumed as it is furnished by nature. Many alimentary substances are disagreeable, and some even poisonous, until they have undergone certain preparations. Few of them are to be had at all seasons of the year, although produced at others in greater quantity than can be consumed; and all of them occur of very different qualities. Hence the selection, preservation, and preparation of alimentary substances, are arts of primary importance in life.

We hold the contempt with which cookery is very generally spoken of, to be downright affectation, we had almost said hypocrisy; for, in the practice of life, every individual who is not perfectly imbecile and devoid of understanding, is an epicure in his own way. The epicures in the boiling of potatoes even are innumerable; and every school-boy in Scotland passes a judgment on the culinary skill of the servant who makes his porridge. Cookery only becomes truly degrading when it occupies an undue proportion of attention; and that epicurism is to be utterly condemned, which produces more pain than pleasure. Boswell, the biographer of Johnson, has defined man to be a cooking animal; and in fact, man is the only animal which does not consume his food as presented to him by nature. We are not from this to conclude, that man in cooking deviates from the ordinary course of nature; but that the appetite for cooked food is given to him for wise and useful ends. Count Rumford has not considered the pleasure of eating, and the means that may be employed for increasing it, as unworthy the attention of a philosopher.

" The enjoyments which fall to the lot of the bulk of mankind are not so numerous as to render an attempt to increase them superfluous. And even in regard to those who have it in their power to gratify their appetites to the utmost extent of their wishes, it is surely rendering them a very important service to show them how they may increase their pleasures without destroying their health.

" If a glutton can be made to gormandize two hours upon two ounces of meat, it is certainly much better for him, than to give himself an indigestion by eating two pounds in the same time.

" The pleasure enjoyed in eating depends first upon the agreeableness of the taste of the food; and secondly, upon its power to affect the palate. Now there are many substances extremely cheap, by which very agreeable tastes may be given to food; particularly when the basis or nutritive substance of the food is tasteless; and the effect of any kind of palatable solid food (of meat, for instance) upon the organs of taste, may be increased almost indefinitely, by reducing the size of the particles of such food, and causing it to act upon the palate by a larger surface. And if means be used to prevent its being swallowed too soon, which may be easily done by mixing with it some hard and tasteless substance, such as crumbs of bread rendered hard by toasting, or any thing else of that kind, by which a long mastication is rendered necessary, the enjoyment of eating may be greatly increased and prolonged.

" The idea of occupying a person a great while, and affording him much pleasure at the same time, in eating a small quantity of food, may perhaps appear ridiculous to some; but those who consider the matter attentively, will perceive that it is very important. It is, perhaps, as much so as any thing that can employ the attention of the philosopher."

But we shall consider cookery in another point of view, and that one, the importance of which will not be denied by the most austere philosopher. The political economists have extolled agriculture above all other arts, and have obtained the assent of mankind to their dogma, that he who makes two blades of grass grow where only one grew before, is a benefactor to his race. And why? Truly because he thus increases the quantity of food, and enables the world to support a larger population. And is not he, who by his skill enables the raw material, whether corn or flesh, furnished to him by the agriculturist, to feed a larger population, or who renders articles alimentary which were formerly rejected, equally a benefactor of his race? Again, every country has its own favourite articles of food, and modes of preparing them; and there is perhaps no subject in regard to which local prejudices are so strong. Now, by bringing these to the test of comparison upon scientific principles, much good would ultimately arise by the gradual introduction into each country, of whatever was worthy of imitation in the practice of other nations.

The learned Krunitz, in his voluminous *Economico-Technologic Encyclopedia*, has anticipated many of our views of the subject. " The preparation of good food, and the directions for this purpose contained in cookery books, are commonly very much despised, or rather altogether neglected, by literary men. But in itself cookery does not deserve this contempt, for it is an important part of domestic economy. Upon its due practice depend the health and comfort of families, which must inevitably suffer from errors committed in it. The reason of this contempt is to be found in the manner in which it has hitherto been treated in cookery books, which have been prepared by common cooks, as they are accustomed to dress a ragout. Since the economical arts in general have been discussed scientifically, it is now time that the same attention should be paid to cookery, which is so generally useful, and which is capable of being considered in so many points of view. But then a totally different course, from that commonly followed, must be pursued. A man of much knowledge, especially physical, chemi-

cal, and dietetical, must condescend to apply to the making experiments on vulgar and refined cookery, and collect the whole into a system, as has been done long since, in regard to the knowledge and preparation of medicines. What has been written upon dietetics, by Züekert, Bergius, Lorry, Plenk, and others, must be compared with the practices in different countries, and a general view of the whole must be drawn up and arranged in systematic order. In regard to the preparations themselves, certain fixed processes and principles are to be determined, general operations to be accurately described, and new improvements to be brought forward. After this the subject might be treated in detail, and a variety, first of simple, then of more compound articles, with the best modes of preparing each as to palatableness, and in relation to effect upon the health, should be perspicuously and thoroughly described. Lastly, their combination into bills of fare, adapted to different ranks in society, modes of life, various tastes, the season of the year, &c. should be pointed out particularly, and with a due regard to good economical arrangements."

No such cookery book has, however, been written; but we hope to be able to give a more scientific view than has hitherto been taken of the subject, under the head of FOOD.

To the list of valuable publications on the subject of dietetics, given in the body of the work (MATERIA MEDICA, Part I.), may be added,

Zoonomia, by Erasmus Darwin, M. D. 2 vols. 4to, London, 1796, for the article Nutrientia, in *Materia Medica*, Vol. II. p. 654.—*Dictionnaire des Sciences Medicales*, Tom. Paris, 1812, et seq.; particularly articles *Alimens*, by Halle and Nysten; *Diéte* and *Diététique*, by Barbier; *Digestion*, by Chaussier and Adelon.—Johann Hermann Beeker's *Versuch einer allgemeinen und besonderen Nahrungsmittelkunde*, Erster Theil, Drey Abtheilungen, 8vo, Stendal, 1810–1812.—Ludwig Vogel, *Diätetisches Lexicon*, 2 Bände, 8vo, Erfurt, 1800–1801.—Johannis Frederici Zuekert, *Materia Alimentaria*, 8vo, Berolini, 1769.—Johann Friederich Zuckert, *Allgemeine Abhandlung von der Nahrungsmitteln mit Anmerkungen*, von Kurt Sprengel, 1796; also *Medicinisches Tischbuch*, 8vo, Berlin, 1785.—Johann George Reyher, *Allgemeine pathologische Diaet*. 8vo, Schwerin, 1790.—Bengt Bergius *über die Leckereyen*, 2 Theile, 8vo, Halle, 1792.—Melchior Sebiz *de Alimentorum facultatibus, libri* v. 4to, Argentor. 1650.—Georg. Gottl. Richter, *Praecepta Diaetetica in usum Prelectionum Academicarum accomodata*, 8vo, Heidelb. 1780.—Louis Lemery *Traité des Alimens*. Troisième edition, par Bruhier, 2 vols. 12mo, Paris, 1755.—Amie Charles Lorry, *Essai sur l' Usage des Alimens, pour servir de Commentaires aux livres Dietetique d'Hippocrate*, Nouvelle edition, 2 vols. 12mo, Paris, 1781.—Otto Staab, *Potagraphie*, 8vo. Frankf. 1807.—Joannis Bruyerini, *Cibus Medicus*, 8vo. Lugd. B. 1560. (X.)

DIFFERENTIAL CALCULUS. The Differential Calculus was embarrassed for many years after its first appearance, by considerations of Motion, Limits, and Infinitesimals. Our countryman, Landen, having made an ineffectual attempt to remove these difficulties, the subject was taken up by Arbogast, who completely new-modelled the Calculus, and founded it upon a pure analytical basis. The genius of La Grange first established the new system, but left the theory obscure and the practical application inconvenient; by attempts to demonstrate matters of definition; by innovations in the notation; and by the universal substitution of the differential coefficients for the differentials themselves. Many of these defects were pointed out by Mr Woodhouse; and the following propositions present a systematic view of the calculus in its latest form, with some farther modification of the principles, and some generalization of the formulæ.

DEFINITIONS.

1. If $f(x+h)$ can be expanded in the form

$$f(x)+\underset{1}{f}(x)\,.\,h+\underset{2}{f}(x)\,.\,h^2+\ldots$$

Then $\underset{1}{f}(x)$ is called the *differential function* of $f(x)$, and its relation to $f(x)$ is thus expressed, $\underset{1}{f}(x)=\mathrm{D}f(x)$.

2. If $(x+h)$ be put under the form $(x)+\mathrm{D}(x)\,.\,h$, it appears that $\mathrm{D}x=1$. This, however, is entirely arbitrary, and unity is merely selected for convenience, since by defining the differential function to be the coefficient in the second term of $f(x+a\,.\,h)$ expanded, we should have had $\mathrm{D}\,x=a$. Similarly $(c)=(c)+\mathrm{D}\,(c)\,.\,h$, and $\mathrm{D}\,(c)=o$.

3. In different functions of the same *principal variable* (x), we may avoid a perpetual reference to (x), and have the advantage of considering such functions as independent variables, by means of another symbol, which shall denote expressions *proportional* to the differential functions. Thus $d\varphi(x)$, $d\Psi(x)$ are called *differentials*, and are merely limited to satisfy the equation, $\mathrm{D}\varphi(x)\times d\Psi(x)=\mathrm{D}\Psi(x)\times d\varphi(x)$.

4. Hence du, dz, dv, &c. are expressions proportional to the differential functions of u, z, v, &c., considered as functions of some variable, the same in all of them.

5. If in the equation $\mathrm{D}\varphi(x)\,.\,d\Psi(x)=\mathrm{D}\Psi(x)\,.\,d\varphi(x)$, we take $\varphi(x)=(x)$, then $\mathrm{D}(x)\,.\,d\Psi(x)=\mathrm{D}\Psi(x)\,.\,dx$, or $d\Psi(x)=\mathrm{D}\Psi(x)\,.\,dx$.

6. If there are several characteristics, D only refers to the first, thus $\mathrm{D}\underset{2}{f}\,\underset{1}{f}(x)=\mathrm{D}\underset{2}{f}\left\{\underset{1}{f}(x)\right\}$, $\mathrm{D}\underset{2}{f}$ being always regarded as a single symbol.

PROP. I.—*To find the Differential of a Function with successive Characteristics.*

Let the function be $\underset{n}{f}\ldots\underset{2}{f}\underset{1}{f}(x)$, then

$$d\underset{n}{f}\ldots\underset{2}{f}\underset{1}{f}(x)=\mathrm{D}\underset{n}{f}\underset{n-1}{f}\ldots\underset{1}{f}(x)\times d\underset{n-1}{f}\ldots\underset{1}{f}(x)$$

$$=dx\times\mathrm{D}\underset{1}{f}(x)\times\mathrm{D}\underset{2}{f}\underset{1}{f}(x)\times$$

$..\mathrm{D}\underset{n}{f}..\underset{1}{f}(x)$ by continuing the same process.

Cor. If $\underset{1}{f}=\underset{2}{f}=\underset{n}{f}=f$, Then

$$df^{n}(x)=dx\times\mathrm{D}f(x)\times\mathrm{D}ff(x)\times..\mathrm{D}ff^{n-1}(x).$$

PROP. II.—*To find the Differential of an Inverse Function.*

If $f(x)=z$, and if (x) found in terms of z, give $x=\mathrm{F}(z)$, then F is represented by f^{-1} the inverse form of f, and $f^{-1}(x)$ is called the *inverse* function of $f(x)$. Now, as we may frequently know the differential of f, our object is to determine the differential of f^{-1} by means of it. Since

$$x=ff^{-1}(x),\ dx=\mathrm{D}ff^{-1}(x)\times df^{-1}(x)$$

$$\therefore df^{-1}(x)=\frac{dx}{\mathrm{D}ff^{-1}(x)}$$

PROP. III.—*To find the Differential of a Function involving independent Characteristics.*

Let the function be $\mathrm{F}\left\{\underset{1}{f}(x),\underset{2}{f}(x),\ldots\underset{n}{f}(x)\right\}$ in which the characteristics $\underset{1}{f},\underset{2}{f},\underset{n}{f}$ contained under F are wholly independent of each other. If the differential function be taken on the supposition, that only one of these independent functions contains x, the expression is called a *partial differential function*, and $\underset{1}{\mathrm{D}}\,\mathrm{F}\left\{\underset{1}{f}(x),..\underset{n}{f}(x)\right\}\times\mathrm{D}\underset{1}{f}(x)$, $\underset{n}{\mathrm{D}}\,\mathrm{F}\left\{\underset{1}{f}(x),..\underset{n}{f}(x)\right\}\times\mathrm{D}\underset{n}{f}(x)$ may denote such partial differential functions, taken with regard to $\underset{1}{f}(x)$ and $\underset{n}{f}(x)$ respectively. The general differential function of $\mathrm{F}\left\{\underset{1}{f}(x),..\underset{n}{f}(x)\right\}$ may be ascertained, if we successively expand $\mathrm{F}\left\{\underset{1}{f}(x+h),..\underset{n}{f}(x+h)\right\}$ by means of its partial differential functions; for it will become

$$\mathrm{F}\left\{\underset{1}{f}(x),..\underset{n}{f}(x+h)\right\}+\underset{1}{\mathrm{D}}\mathrm{F}\left\{\underset{1}{f}(x),..\underset{n}{f}(x+h)\right\}\times\mathrm{D}\underset{1}{f}(x)\times h+\&c.$$

and finally, by continuing the same operations, we shall find the coefficient of (h) to be

$$\underset{1}{\mathrm{D}}\,\mathrm{F}\left\{\underset{1}{f}(x),..\underset{n}{f}(x)\right\}\times\mathrm{D}\underset{1}{f}(x)+..\underset{n}{\mathrm{D}}\,\mathrm{F}\left\{\underset{1}{f}(x),\ \underset{n}{f}(x)\right\}\times\mathrm{D}\underset{n}{f}(x),$$

from which it appears, that the general differential function is the sum of all the partial differential functions, and that it is indifferent in what order they are taken, whether $\underset{1}{\mathrm{D}}$, in respect of $\underset{1}{f}(x)$, or $\underset{n}{\mathrm{D}}$ in respect of $\underset{n}{f}(x)$.

Cor. 1. $d\mathrm{F}\left\{\underset{1}{f}(x),\ ..\underset{n}{f}(x)\right\}$

$$=\underset{1}{\mathrm{D}}\mathrm{F}\left\{\underset{1}{f}(x),..\right\}\times\mathrm{D}\underset{1}{f}(x)\times dx+..$$

$$=\underset{1}{\mathrm{D}}\,\mathrm{F}\left\{\underset{1}{f}(x),..\right\}\times d\underset{1}{f}(x)+..$$

Cor. 2. If we substitute for $\underset{1}{f}(x)$, $\underset{2}{f}(x)$, .. the independent variables $u, z, \ldots$, it appears that

$$d\mathrm{F}\left\{u,z,..\right\}=\underset{1}{\mathrm{D}}\mathrm{F}\left\{u,z,..\right\}.du+\underset{2}{\mathrm{D}}\,\mathrm{F}\left\{u,z,..\right\}.dz+..$$

Cor. 3.—If the partial differentials be denoted by $\underset{1}{d}$, $\underset{2}{d}$, .. and if the characteristics be separated, we have $d=\underset{1}{d}+\underset{2}{d}+..\underset{n}{d}$

Cor. 4. If we denote the partial differential taken with regard to (u) by $\frac{d}{du}\mathrm{F}\left\{u,z,..\right\}.du$, and the rest similarly, and if Q be substituted for $\mathrm{F}\left\{u,z,..\right\}$, $d\,\mathrm{Q}=\frac{d}{du}\mathrm{Q}.du+\frac{d}{dz}\mathrm{Q}.d\,z+..$, which very elegant notation is used by Mr Babbage in the *Transactions of the Royal Society of London.*

Cor. 5.—By combining the present proposition with Prop. 1., we are enabled to find the differentials of the intricate expressions in Mr Babbage's *Calculus of Functions.*

Lemma.—To enumerate and arrange the primary relations of which analysis consists.

1. In order to exhibit the relations subsisting among the successive functions $x+a$, $x\times a$, x^{a}, it will be necessary to present them under a different form of notation. Let

$$x\,\underline{1}\,a=x+a$$

$$x\,\underline{2}\,a=x\times a$$

$$=x+\left\{x+\left\{..\text{to }(a)\text{ terms.}\right.\right.$$

$$x\,\underline{3}\,a=x^{a}$$

$$=x\times\left\{x\times\left\{..\text{to }(a)\text{ terms.}\right.\right.$$

$$x\,\underline{4}\,a=x^{x^{x^{..}}}..\text{to }(a)\text{ terms.}$$

Then generally

$$x\,\underline{n+1}\,a=x\,\underline{n}\left\{x\,\underline{n}\left\{..\text{to }(a)\text{ terms.}\right.\right.$$

These are called primary *direct* relations.

2. The primary *inverse* relations are found by determining z from the equation $z \overset{n}{-} a = x$. They are $x - a$, $x \div a$, $\sqrt[a]{x}$, &c.

3. The primary *reciprocal* relations are represented by $a \overset{n}{-} x$, (a) and (x) being interchanged, and are $a + x$, $a \times x$, a^x, $a^{a^{\cdot\cdot}}$ to (x) terms, &c.

4. The primary *inverse reciprocal* relations are found by determining (z) from the equation $a \overset{n}{-} z = x$, thus from $x = a \overset{3}{-} z = a^z$ is deduced log (x) base (a).

5. By taking alternately the reciprocal and inverse forms of the first three relations, we shall find that they circulate and only introduce known functions. Thus x^a becomes ax, log (x) base (a), log (a) base (x), $a^{\frac{1}{x}}$, $x^{\frac{1}{a}}$, x^a.

6. Every finite expression now used, is composed of these primary relations. It cannot therefore be a matter of surprise that analysis should frequently present expressions appearing to pass into each other discontinuously and without a law, when the laws of succession in these fundamental forms have never been stated; and the functions beyond $x \overset{4}{-} a$ have not even been mentioned.

Prop. IV.—*To find the Differentials of Functions under the first relation.*

If the expression be $\underset{1}{f}(x) + \underset{2}{f}(x)$,

$$\underset{1}{f}(x+h) + \underset{2}{f}(x+h) = \left\{ \begin{array}{l} \underset{1}{f}(x) + \mathrm{D}\underset{1}{f}(x) \cdot h + \cdot \\ + \underset{2}{f}(x) + \mathrm{D}\underset{2}{f}(x) \cdot h + \cdot\cdot \end{array} \right.$$

$$= \underset{1}{f}(x) + \underset{2}{f}(x) + \left\{ \mathrm{D}\underset{1}{f}(x) + \mathrm{D}\underset{2}{f}(x) \right\} \cdot h + \cdot\cdot$$

$$\therefore \mathrm{D} \left\{ \underset{1}{f}(x) + \underset{2}{f}(x) \right\} = \mathrm{D}\underset{1}{f}(x) + \mathrm{D}\underset{2}{f}(x)$$

Similarly

$$\mathrm{D} \left\{ \underset{1}{f}(x) - \underset{2}{f}(x) \right\} = \mathrm{D}\underset{1}{f}(x) - \mathrm{D}\underset{2}{f}(x)$$

Cor. 1. $d \left\{ \underset{1}{x} \pm \cdot\cdot \underset{n}{x} \right\} = d\underset{1}{x} \pm \cdot\cdot d\underset{n}{x}$

Cor. 2. $\mathrm{D} \left\{ f(x) \pm a \right\} = \mathrm{D}f(x) \pm \mathrm{D}(a) = \mathrm{D}f(x)$

Cor. 3. $d(x \pm a) = dx$, $d(a \pm x) = \pm dx$.

Prop. V.—*To find the Differentials of Functions under the second relation.*

If the expression be $\underset{1}{f}(x) \times \underset{2}{f}(x)$,

$$f(x+h) \times \underset{2}{f}(x+h) = \left\{ \begin{array}{l} \underset{1}{f}(x) + \mathrm{D}\underset{1}{f}(x) \cdot h + \cdot\cdot \\ \times \\ \underset{2}{f}(x) + \mathrm{D}\underset{2}{f}(x) \cdot h + \cdot\cdot \end{array} \right.$$

$$= \underset{1}{f}(x) \times \underset{2}{f}(x) + \left\{ \mathrm{D}\underset{1}{f}(x) \cdot \underset{2}{f}(x) + \mathrm{D}\underset{2}{f}(x) \cdot \underset{1}{f}(x) \right\} \cdot h + \cdot\cdot$$

$$\therefore \mathrm{D} \left\{ \underset{1}{f}(x) \times \underset{2}{f}(x) \right\} = \mathrm{D}\underset{1}{f}(x) \cdot \underset{2}{f}(x) + \mathrm{D}\underset{2}{f}(x) \cdot \underset{1}{f}(x).$$

By a process nearly similar,

$$\mathrm{D} \left\{ \underset{1}{f}(x) \div \underset{2}{f}(x) \right\} = \frac{\mathrm{D}\underset{1}{f}(x) \cdot \underset{2}{f}(x) - \mathrm{D}\underset{2}{f}(x) \cdot \underset{1}{f}(x)}{\underset{2}{f}(x)^2}$$

Cor. 1. $d \left\{ \underset{x}{\overset{\times}{x}} \div \cdot\cdot \underset{n}{x} \right\} = \underset{1}{\overset{\times}{x}} \div \cdot\cdot \underset{n}{x} \times \left\{ \frac{d\underset{1}{x}}{\underset{1}{x}} \pm \cdot\cdot \frac{d\underset{n}{x}}{\underset{n}{x}} \right\}$

Cor. 2. $\mathrm{D} \left\{ f(x) \times a \right\} = \mathrm{D}f(x) \times a.$

Cor. 3. $d \left\{ x \times a \right\} = dx \times a.$

$$d \left\{ a \div x \right\} = -\frac{a \cdot dx}{x^2}$$

Prop. VI.—*To find the Differentials of Functions under the third relation.*

If the expression be $f(x)^a$,

$$f(x+h)^a = \left\{ f(x) + \mathrm{D}f(x) \cdot h + \cdot\cdot \right\}^a$$

$$= f(x)^a + a \cdot f(x)^{a-1} \cdot \mathrm{D}f(x) \cdot h + \cdot\cdot$$

$$\therefore \mathrm{D} \left\{ f(x)^a \right\} = a \cdot f(x)^{a-1} \cdot \mathrm{D}f(x).$$

If the expression be $a^{f(x)}$,

$$a^{f(x+h)} = a^{f(x) + \mathrm{D}f(x) \cdot h + \cdot\cdot}$$

$$= a^{f(x)} \times a^{\mathrm{D}f(x) \cdot h} \times \cdot\cdot$$

$$= a^{f(x)} \times \left\{ 1 + \mathrm{L}(a) \cdot \mathrm{D}f(x) \cdot h + \cdot\cdot \right\} \times$$

$$= a^{f(x)} + \mathrm{L}(a) \cdot a^{f(x)} \cdot \mathrm{D}f(x) \cdot h + \cdot\cdot$$

$$\therefore \mathrm{D} \left\{ a^{f(x)} \right\} = \mathrm{L}(a) \cdot a^{f(x)} \cdot \mathrm{D}f(x)$$

If the expression be $\log f(x)$ base (a) or $\frac{\mathrm{L}f(x)}{\mathrm{L}(a)}$, L denoting the Napierean logarithm,

$$\mathrm{L}f(x+h) = \mathrm{L} \left\{ f(x) + \mathrm{D}f(x) \cdot h + \cdot\cdot \right\}$$

$$= \mathrm{L}f(x) + \mathrm{L} \left\{ 1 + \frac{\mathrm{D}f(x)}{f(x)} \cdot h + \cdot\cdot \right\}$$

$$= \mathrm{L}f(x) + \frac{\mathrm{D}f(x)}{f(x)} \cdot h + \cdot\cdot$$

$$\therefore D\left\{\log f(x)\right\} = \frac{Df(x)}{L(a) \cdot f(x)}$$

Also, $D\left\{\log\ (a)\ \text{base} f(x)\right\} = D\frac{L(a)}{Lf(x)}$ which is known.

Cor. 1. $d(x_1^{x_2}) = d_1(x_1^{x_2}) + d_2(x_1^{x_2})$

$$= x_2 \cdot x_1^{x_2 - 1} \cdot dx_1 + L x_1 \cdot x_1^{x_2} dx_2$$

Cor. 2. $d\left\{x^a\right\} = ax^{a-1} \cdot dx$

$$d\left\{a^x\right\} = La \cdot a^x \cdot dx$$

$$d\left\{\log\ (x)\right\} = \frac{dx}{La \cdot x}$$

The first three propositions will enable us to extend these formulæ to every finite function at present used in analysis, but when we attempt to find the differentials in relations of a higher order, the difficulties increase very rapidly. Indeed, the direct calculus, which is generally considered perfect, is only less limited than the inverse. Let the most expert analyst attempt, in analogy to Prop. 2, to express the differential of the reciprocal function $f(a,x)$, by means of the direct function $f(x, a)$; let him endeavour to develope $(x+h) \frac{n}{\ } a$ in analogy to Sir Isaac Newton's expansion of $(x+h) \frac{3}{\ } a$; or let him search for the differential of $a \frac{1}{\ } x = a^{a^{\cdot^{\cdot}}}$ to (x) terms, and he will be forced to admit the great imperfections of the instrument.

Prop. VII.
To find Successive Differentials.

If we take the differential of $Df(x)$ considered as a new function, we obtain the second differential function $D\left\{Df(x)\right\}$, which is represented by $D^2 f(x)$, and, in the same manner, we may find the value of $D^n f(x) = D\left\{D\left\{\ldots Df(x)\right.\right.$. The laws observed by the successive differentials of the functions previously examined are very complex, and can only be expressed by separating the differential characteristics, and operating upon them as independent symbols.

Prop. VIII.—*To find the Coefficients of the Differential Expansion.*

Since $f\left\{x + (i+h)\right\} = f\left\{(x+h) + i\right\}$, we develope these expressions separately, and equate their homologous terms. The first becomes

$$f(x) + f_1(x) \cdot (i+h) + f_2(x) \cdot (i+h)^2 + \ldots$$

which is equal to

$$f(x) + f_1(x) \cdot i + f_2(x) \cdot i^2 + \ldots$$
$$+ f_1(x) \cdot h + f_2(x) \cdot 2ih + \ldots$$
$$+ \ldots$$

The second becomes

$$f(x+h) + f_1(x+h) \cdot i + f_2(x+h) \cdot i^2 + \ldots$$

which is equal to

$$f(x) \quad + f_1(x) \quad + f_2(x) \quad + \ldots$$
$$+ Df(x) \cdot h + Df_1(x) \cdot ih + Df_2(x) \cdot i^2 h + \ldots$$
$$+ \ldots$$

And now, by equating the same powers of i and h, in the second terms of each developement, $f_1(x) = Df(x)$; $f_2(x) \cdot 2 = Df_1(x)$; $f_3(x) \cdot 3 = Df_2(x)$; $f_n(x) \cdot n = Df_{n-1}(x)$.

$$\therefore f_n(x) = Df_{n-1}(x) \cdot \frac{1}{n}$$
$$= D^n f(x) \times \frac{1}{1 \cdot 2 \ldots n}$$

Hence $f(x+h)$ becomes

$$f(x) + Df(x) \cdot \frac{h}{1} + \ldots D^n f(x) \cdot \frac{h^n}{1 \cdot 2 \ldots n} + \ldots$$

Cor. 1. $f(x) = f(o + x)$

$$= f(o) + Df(o) \cdot \frac{x}{1} + D^2 f(o) \cdot \frac{x^2}{1.2} + \ldots$$

Cor. 2. $D^{-1} f(x)$ is the *inverse* differential function, and is of such a nature that $D\left\{D^{-1} f(x)\right\} = f(x)$.

$$D^{-1} f(x) = D^{-1} f\left\{a + (x-a)\right\} =$$

$$D^{-1} f(a) + f(a) \cdot \frac{x-a}{1} + Df(a) \cdot \frac{(x-a)^2}{1 \cdot 2} + \ldots$$

where $D^{-1} f(a)$ is the value of $D^{-1} f(x)$, when $x = a$, and it is called the *Correction*.

Cor. 3. $D^{-1} f(a) = D^{-1} f\left\{x + (a-x)\right\} =$

$$D^{-1} f(x) + f(x) \cdot \frac{a-x}{1} + Df(x) \cdot \frac{(a-x)^2}{1 \cdot 2} + \ldots$$

$$\therefore D^{-1} f(x) = D^{-1} f(a) - f(x) \cdot \frac{a-x}{1} - Df(x) \cdot \frac{(a-x)^2}{1 \cdot 2} - \ldots$$

From these theorems the inverse calculus may be deduced by *direct* processes.

Cor. 4. There is nothing in the nature of analysis which necessarily limits expansions to the differential form. The series may be conceived to proceed by other functions of x and h; it even may not consist of a succession of sums, but may ascend by products, or according to any other relation. Thus we may find the successive terms of $(x \times \varepsilon^h)$ when developed in the form

$$f(x) \times \underset{1}{f}(x)^{h} \times \underset{2}{f}(x)^{h^2} \times \ldots$$

For, let $\underset{1}{f}(x)$ be called the *factorial function* of $f(x)$, and let its relation to $f(x)$ be thus expressed, $\underset{1}{f}(x) = \mathrm{P}f(x)$; then by expanding

$$f(x \times \varepsilon^{i+h}) = f(x \cdot \varepsilon^{h} \times \varepsilon^{i})$$

and by equating the like powers of i and h, we shall find $f(x \times \varepsilon^{h})$ become

$$f(x) \times \mathrm{P}f(x)^{\frac{h}{1}} \times \mathrm{P}^2 f(x)^{\frac{h^2}{1.2}} \times \ldots$$

a theorem entirely analogous to that of Taylor, and presenting a *factorial calculus* on principles similar to the differential. It is not, however, necessary to deduce the values of $\mathrm{P}f(x)$, by making it the subject of distinct investigations, since Mr Herschel, on seeing the formula, has discovered an expression for $\mathrm{P}f(x)$ by means of $\mathrm{D}f(x)$, and observes, that the factorial calculus so harmonizes with the differential, that either may be established, and the other deduced from it.

Differentials depend upon the developement of $f\left\{x \underline{1}\, a \underline{2}\, h\right\}$, factorials upon $f\left\{x \underline{2}\, a \underline{3}\, h\right\}$, and it is obvious that a wide field is open for $f\left\{x \underline{n}\, a \underline{m}\, h\right\}$. Mr Whewell further suggests the idea of an expansion, in which the relation of the successive terms shall be expressed by a functional characteristic.

The object of the calculus is not to show that every function of the form $f(x + h)$ must necessarily proceed by integer powers of h. The legitimate design is to exhibit the relation subsisting among the successive terms, and to find the value of $\mathrm{D}f(x)$ in complex expressions, by means of the values in the primary functions. It supposes the general form of developement given, and leaves the determination of the second terms, in the expansion of the primary functions, to the artifices of the ordinary algebra.

PROP. IX.—*To find the Differentials of Continuous Quantities.*

Let (x) be a known discrete variable, and let any continuous quantity, which varies with (x), be represented by $\Psi(x)$, an unknown function of (x). If then x becomes $x + h$, $\Psi(x)$ becomes $\Psi(x + h)$, and we obtain the following equal ratios:

$$\Delta x : \Delta \Psi(x)$$
$$(x + h) - x : \Psi(x + h) - \Psi(x)$$
$$h : \mathrm{D}\Psi(x) \,.\, h + \ldots$$
$$1 : \mathrm{D}\Psi(x) + \mathrm{D}^2\Psi(x) \,.\, \frac{h}{1.2} + \ldots$$

Let Q and Q′ be discrete known variables, one always greater, and the other always less than $\Delta \Psi(x)$. Also, let the ratios

$$\Delta x : \mathrm{Q} \text{ and}$$
$$\Delta x : \mathrm{Q}'$$

be such, that both may be made to approach nearer than by any assignable difference, to the ratio

$$1 : f(x).$$

Then, since Q and Q′ are one greater and the other less than $\Delta \Psi(x)$, the ratio of

$$1 : f(x)$$

cannot possibly differ from that ratio to which

$$\Delta x : \Delta \Psi(x), \text{ or}$$
$$1 : \mathrm{D}\Psi(x) + \ldots$$

approaches nearer than by any assignable difference. It may further be proved, that the only ratio which can be true is,

$$1 : f(x) :: 1 : \mathrm{D}\Psi(x)$$
$$\therefore \mathrm{D}\Psi(x) = f(x), \text{ and}$$
$$\Psi(x) = \mathrm{D}^{-1} f(x).$$

If, therefore, we are investigating any curve, or the motion of any body, where the analytical value is unknown, Newton lays it down as a *practical rule* for finding the differentials, that they will be in the *limiting ratio* of the corresponding increments, viz. in the ratio to which the increments approach nearer than by any assignable difference. This practical rule, offered by the great inventor, may be demonstrated *ex absurdo*, with all the rigour of the ancient geometry. The formula of Taylor not having been distinctly expressed, Newton could not lay down the analytical theory of his calculus, but he left a *practical rule*, which is the best that has yet been proposed, and he left an *illustration*, the most beautiful in the circle of the sciences. He compared the differentials to the velocities of a body in motion. Many modern writers still define differentials by means of the limiting ratio; but this is as inconsistent, as it would be to define multiplication by the mechanical rule for finding the product. The method of infinitesimals is now universally exploded, having been originally proposed by Leibnitz, who, perceiving that Newton's results depended solely on the second terms, supposed that his calculus must consist in making the subsequent terms vanish. The results were here happily correct, though a similar attempt to appropriate the theory of gravitation was wholly unsuccessful. The latest English work on this branch of analysis, is the *Translation of La Croix's Treatise*, where Mr Peacock gives a luminous view of the different theories on the subject. (X. X.)

DILLENIUS (JOHN JAMES), a distinguished botanist of the eighteenth century, who may be called the father of cryptogamic botany, was born at Darmstadt, in 1687. He was educated as a physician, in the University of Giessen, but his attention was very early diverted from medical studies, to the observation and discrimination of plants, nor does he appear ever to have followed any branch of the practice of physic. In botany he was strictly a practical observer, having addicted himself but little to the principles of classification, and not at all to the physiology of vegetables. Some branches of Zoology occasionally engaged him, which an assiduous collector of plants, in their native situations, can hardly escape, so closely are these studies, especially that of insects and the lower tribes of animated

beings, connected with botany. Dillenius, while at Giessen, wrote several papers for the *Ephemerides Naturæ Curiosorum*, on American plants naturalized in Europe; on coffee; on opium obtained from poppies in Germany; with some minute critical remarks on *Spergula pentandra*, as well as on various cryptogamous plants. He published also a paper on leeches, and two species of *papilio*. He printed at Giessen, in 1719, his *Catalogus Plantarum spontè circa Gissam nascentium*, a valuable little 8vo volume, with figures drawn and engraved by his own hand, of the parts of fructification, particularly designed to illustrate the generic characters of plants, previously not well arranged or understood. In this work he established many new genera, which have for the most part kept their ground. His great merit, as a general botanist, consisted in a constant attention to the only sound principle of scientific botany, the discrimination of *genera* by the parts of the flower and fruit. This principle, first proposed by the great Conrad Gesner, Dillenius applied to practice, with a severer judgment and closer attention, than perhaps any other person, from Gesner to Linnæus. The little book in question is arranged, most inconveniently, according to the times of the plants' flowering. Its preface, however, enters into the subject of classification, a subject to which young botanists are generally prone, but of which they, as generally, after having embroiled it, take their leave, in proportion as they acquire more practical knowledge. Dillenius so far displayed his judgment, that he rather showed the faults of the systems of Tournefort, Knaut, and Rivinus, than offered any thing of his own. This led him into some controversies, from which he soon disengaged himself, and never subsequently took up the question at all.

The great William Sherard, returning in 1718 from Smyrna, through Germany, met with Dillenius, whose scientific merit could not have escaped so eminent a botanist. He brought him to England in 1721, and excited him to publish, in 1724, that valuable enlarged edition of Ray's *Synopsis* of British plants, which has ever since been in general use, and which the editor enriched with engravings of his own. In this publication, compared with the *Catalogus* of the plants of Giessen above-mentioned, we cannot but perceive the difference between an author, working upon his own original materials, and the commentator or illustrator of the labours of another. Though Dillenius made numerous and correct additions to Ray's work, in the cryptogamic tribes at least, he rather confused than improved the other parts of the book, especially with regard to synonyms, in which department he was never supremely accurate.

In 1732 Dillenius published his magnificent *Hortus Elthamensis*, in two volumes, folio, containing 324 plates, engraved on pewter, with his own hand. Their merit consists in their great precision and fidelity. The descriptions, and historical, as well as botanical remarks, render this a classical book in botany. Its style is good, and the whole performance is worthy of the author, and of his eminent patron, whose brother, Dr James Sherard, was the owner of the garden at Eltham, which furnished the rich materials of this publication. Before this book appeared, its author was established at Oxford, in the new professorship founded there by the will of William Sherard, who died in August 1728, and who left L. 3000 for the purpose, besides his own library, manuscripts, and ample herbarium. Dillenius took the degree of M. D. in this university in 1735, though he had previously obtained the same rank at Giessen; and he now devoted himself to the completion of the *Pinax*, or universal collection of synonyms, which was Sherard's chief object in this foundation. The work was never finished; for, indeed, neither Dillenius, nor any one else, could, even at that time, be competent to it: still less, as botanists and botanical works multiplied excessively, was this undertaking practicable. The publications of Linnæus soon rendered it unnecessary. That illustrious foreigner, in 1736, visited Dillenius, who was desirous of fixing him here as his coadjutor, but to this scheme there were several impediments. Nevertheless, these distinguished men continued ever after in correspondence, certainly to the advantage of their common study, except in one but too important instance. We allude to the theory of the fructification of Mosses, in which Linnæus implicitly adopted the faulty opinion of the Oxford professor, contrary to his own better observation and judgment, taking the capsule for the anther. This leads us to mention the immortal work on which the fame of Dillenius rests, and which, in its way, will never be excelled, the *Historia Muscorum*, published in 1741, in one quarto volume, with 85 plates, drawn and engraved by the author. In this performance, laborious investigation, acute discrimination, supreme accuracy, and profound learning, are displayed beyond all example or comparison. Following inquirers, like the celebrated Hedwig, may, with better helps, have examined the same objects more deeply, but none has taken so complete a view of the subject, nor made so very few mistakes. No botanical book perhaps is so perfect in synonyms. Whether the labour of this undertaking was too much for the health of its author, or whether his sedentary mode of life was, on the whole, injurious, we have no particular information; but he began, soon after the publication of the *Historia Muscorum*, to complain of ill health and advancing age. He was of a short stature and corpulent habit, and died of an apoplexy, April 2, 1747, in his 60th year. A picture of this distinguished botanist is preserved in the picture-gallery at Oxford, from which a print has been published in Sims and Konig's *Annals of Botany*, Vol. II. Dillenius is said to have been amiable and respectable in his private character. He never married. His books, collection of mosses referring to his great work, with many drawings, especially of *Fungi*, were bought by his successor Dr Humphrey Sibthorp, and added to the Sherardian Museum, where they still remain.—Kippis *in Biog. Brit.*—Hall. *Bibl. Bot.*—*Works and Letters of Dillenius.*

(J. J.)

DISTILLATION.

The preparation of ardent spirits constitutes a manufactory which is carried on in this country to a considerable extent, and deserves a particular investigation, as connected with one of the most curious and intricate departments of chemistry. We shall treat the subject as briefly as is compatible with perspicuity and utility.

It seems established by the experiments of chemists, that no other substance can be converted into ardent spirits, by fermentation, than sugar. Different species of sugar have been recognized by chemists. They are distinguished from each other by their sweetening power, and by the figure of their crystals. As far as the process of distillation is concerned, it seems only necessary to refer to three of these species; namely, *common sugar*, *sugar of grapes*, or *sugar of starch* and *manna*.

Common sugar is usually extracted from the sugar cane, but it exists likewise in beet, and in various other vegetable substances. Its colour is white, and it crystallizes in rhomboidal prisms. When it is dissolved in a sufficient quantity of water, and mixed with yeast, it ferments, and the liquid thus fermented yields, when distilled, an ardent spirit. It is from the refuse of common sugar that the ardent spirit, well known by the name of *rum*, is obtained in the West Indies.

Sugar of grapes is the substance to which that fruit is indebted for its sweet taste. It may be extracted from the juice of grapes, by nearly the same process as is followed by the manufacturers of common sugar. It is white, not so sweet as common sugar, and not so soluble in water. It usually crystallizes in spheres. These, when viewed with a glass, are found to consist of a congeries of small acicular crystals, diverging from a centre. It is to the presence of this sugar that the juice of grapes owes its fermentability. The ardent spirits obtained by distilling *wine* are usually distinguished by the name of *brandy*. They are manufactured in great abundance in France and Spain and other wine countries.

When starch is boiled with a large quantity of water and a little sulphuric acid, for a considerable time, it is converted into a sugar, which possesses exactly the properties of sugar of grapes. From the experiments of M. Theodore de Saussure, it seems to follow that this sugar is nothing more than a combination of starch with water. During the process of malting, the starch which constitutes so great a portion of barley is converted into this sugar. If barley meal be mashed with water of the temperature 150^0, and the mixture be well agitated for an hour or two, the barley starch gradually undergoes a process somewhat similar to mashing; for it becomes soluble in the water, and that liquid acquires a sweet taste. It is from this sugar that the ardent spirits, known in this country by the names of *Geneva*, *Whisky*, *Gin*, are obtained.

Manna is a saccharine substance, which exudes spontaneously from the *Fraxinus ornus*, and several other species of ash. The fermented juice of the onion, melon, and carrot, likewise contain manna. Manna has a sweet taste like sugar. It is more soluble both in water and alcohol; it crystallizes very readily on cooling, in needles. But its most remarkable property is, that when dissolved in water, and mixed with yeast, it cannot be made to ferment like common or grape sugar. Hence it is incapable of yielding an ardent spirit. To the distiller, therefore, it is totally useless.

Milk likewise contains a peculiar species of saccharine matter, distinguished by the name of *sugar of milk*. In consequence of the presence of this substance, milk is capable of being fermented into an intoxicating liquor, which, of course, if distilled, would yield an ardent spirit. This liquor is made by the Tartars, from the milk of mares, and is known by the name of *koumiss*. It is made likewise in Shetland.

The liquid which exudes from the cocoa nut tree also contains a saccharine matter, but of what species has not been ascertained. In consequence of the presence of this saccharine matter, it runs readily into fermentation, and when the fermented liquor is distilled, it yields an ardent spirit, well known in India by the name of *arrack*.

Thus the name of the ardent spirit differs according to the material employed in its manufacture. Every species of ardent spirit is distinguished by a peculiar flavour. The opinion entertained at present is, that the nature of the substance which produces intoxication, is the same in all these ardent spirits, and is the substance to which chemists have given the name of *alcohol;* and that the flavour is owing to the presence of an essential oil, derived from the ingredient employed in the manufacture. Thus the sugar cane yields the oil that gives the peculiar flavour to rum; grapes contain the oil that gives the peculiar flavour to brandy, and so on. We do not know that this opinion, though sufficiently probable in itself, has ever been established by decisive experiments; that the oils to which these spirits owe their flavour have ever been obtained in a separate state; or that all of these spirits have been made to yield alcohol, destitute of flavour. But the opinion is so very likely to be true, that we will be forgiven for adopting it, especially as we are not aware of any counter-evidence that can be brought forward.

The processes of the distiller being essentially the same, whatever the substance be from which he procures his *ardent spirits*, we shall satisfy ourselves with a minute account of the processes followed by the distillers in Scotland, in manufacturing whisky.

We shall introduce, likewise, a few observations on the processes followed in manufacturing ardent spirits in other countries, such as Hollands and Rum; and we shall terminate the article by giving the present state of our knowledge of the theory of fermentation.

Chap. I.—Of the Manufacture of Whisky.

The kind of grain employed in this country for manufacturing whisky is *barley*. The processes are easier, and the spirits produced have a more agreeable flavour, when the barley is *malted*. But, in consequence of the duty upon malt, a portion of unmalted grain has been introduced into the distilleries. This portion has been gradually increased, and amounts very commonly to four-fifths, and in some cases, it is said, to nine-tenths of the whole mixture of raw grain and malt. It may be laid down as a general rule, that the labour bestowed, and the time requisite for brewing, increases in proportion to the quantity of raw grain employed.

The processes of the distiller may be reckoned four; namely, the mashing, the cooling, the fermenting, and the distilling. We shall take each of these processes in the order in which we have named them.

I. *The Mashing.*

The barley is previously ground to a fine meal, and the malt bruised by passing it between rollers. When the proportion of malt is very small, it is customary to add a quantity of the *seeds* of oats (the husk of oats separated during the grinding), to facilitate the separation of the water from the grains, after the process of mashing is over. For barley-meal parts with water with much greater difficulty than malt. When the proportion of raw grain to malt is as 2 to 1, or even as 3 to 1, this addition of oat seeds may be dispensed with. But it is probably essential, when the proportions amount to 5 to 1, or, still more, when to 9 to 1.

The quantity of grain and malt employed at one time, must be entirely regulated by the size of the distillery. But, that we may be able to give a precise notion of the proportions of the different substances employed, we shall suppose the quantity taken at once to be 60 bushels, and that it consists of a mixture of 2 parts raw grain, and 1 part malt, or,

40 bushels barley,
20 bushels malt.

The mash-tun is a large circular or square vessel, which now-a-days is usually constructed of cast iron. It was formerly of wood; but a wooden mash-tun was found to last for so short a time, that iron has been substituted in several distilleries with which we are acquainted, and probably the substitution will soon become general. Into the mash-tun a quantity of water is let down of the temperature 150° Fahrenheit. The bulk of this water varies according to the fancy of the distiller. But from 700 to 800 wine gallons may be reckoned a good proportion for sixty bushels of grain. The mixture of meal and bruised malt is then put into the mash-tun, and very carefully mixed with the water by a number of men, who wield each a wooden instrument adapted for the purpose. All the dry clots of meal are broken, and every portion of it wetted with the water. This agitation of the meal in the water is what is technically called *mashing*. It is continued for at least an hour and a half, sometimes much longer; and the length of time must increase with the proportion of raw grain present, when compared with the malt; so that sometimes we have seen it continued for three or even four hours. As the liquor in the mash-tun would lose a great deal of its heat during this length of time, about 500 wine gallons of water are added at intervals, at a temperature varying from 190° to 205° according to the fancy of the brewer. After the mashing is concluded, the whole mixture is allowed to remain at rest for about two hours, and this interval is technically called the *infusion*. During this interval, the grains sink to the bottom, and the *wort*, still muddy, but quite liquid, remains at the surface.

If we have the curiosity to taste the wort every half hour from the commencement of the mashing to the end of the process, we shall find that at first it has little taste, but that it becomes sweeter and sweeter, till at last it acquires very nearly the luscious sweet taste of malt wort. This indicates clearly, that the starch of the barley meal is gradually converted, during the mashing, into starch sugar. In what way this change is produced, we have, at present, no experiments to determine. But, if Theodore de Saussure's theory of the formation of starch sugar be accurate, we may conclude, that the change is produced simply by the combination of a portion of water with the starch. The conversion, however, in the mash-tun, is never complete. A considerable portion of the starch still remains unaltered. The consequence is, that if we endeavour to make wort from raw grain, as strong as possible, to contain, for example, 200 lbs. of saccharine matter *per* barrel, we find ourselves unable to effect our object; because, long before it has reached 200 lbs. *per* barrel, the wort has lost its fluidity, and has assumed the form of a jelly. Our mode of trying this experiment was, to take the strongest raw grain wort which we could procure, and to concentrate it by boiling, till it became as strong as possible. We were never able, by this method, to obtain a wort much stronger than 150 lbs. *per* barrel. But malt wort may be easily boiled down to the strength of 200 lbs. *per* barrel, without losing its fluidity.

Probably the change of the starch into sugar continues during the process of fermentation. Hence, we conceive, the reason why distillers find it advantageous to put into the fermenting tuns all the solid starchy matter which had precipitated from the wort while in the coolers. Hence, also, the reason why the fermentation is conceived to go on best when it comes on gradually at first, and not with too much violence.

After the mashing and infusion is finished, the wort is drawn off from the grains. This is not done, as is the practice with the brewers, by opening a

cock at the bottom of the mash-tun. It will not, in this way, pass through barley meal. But it is drawn off from the top of the mash-tun, after the grains have subsided, by means of a tube pierced full of holes, which rises, at one of the corners of the mash-tun, as high as the surface of that vessel.

The quantity of wort that runs off in this way does not exceed one-third of the water which had been mashed with the meal. If 1200 gallons of hot water, for example, have been employed in all, the wort drawn off after the mashing will scarcely exceed 400 gallons. If the process were carried no farther, almost two-thirds of the wort would be lost. To prevent this, about 500 gallons of water, of the temperature 190°. is let upon the grains. The whole is well mixed together for about twenty minutes, and then allowed to *infuse*, or to remain at rest for an hour and a half. It is then drawn off in the same way as the first wort. In general, the amount of the second wort is greater than of the first, because the grains, having been previously deprived of a great proportion of their starch, now part with their water more freely than before.

To carry off everything soluble from the grains as completely as possible, after the second worts have been drawn off, about 800 gallons of boiling hot water are let on the grains. The mashing or stirring is continued for twenty minutes, and the infusion for half an hour or forty minutes. This third wort is then drawn off. Being much weaker than the two preceding worts, some distillers are in the habit of reserving it, and employing it for mixing with the meal and malt in the succeeding brewing. Others boil it down to the requisite strength, and then mix it with the first and second worts in the fermenting vessel. It is impossible to lay down any rule respecting this part of the process, because, unfortunately, the distiller is not left at liberty to follow his own judgment in this part of the process. The legislature has interfered, and obliged him to produce a determinate quantity of spirits of a given strength from 100 gallons of the fermented wort. Till within these few years it was necessary in Scotland to produce from 100 gallons of fermented wort, 19 gallons of spirits of the strength one to ten over hydrometer proof, or of the specific gravity 0.90917. This law we believe still exists in England; but in Scotland, the quantity of spirits from 100 gallons of fermented wort has been lately reduced to 14 gallons.* The Scotch distiller at present is under the necessity of producing this quantity of spirits from 100 gallons of fermented wort, or, at any rate, of paying the duty for that quantity, whether he produce it or not. This law, of course, regulates the strength of his wort. For, in order to produce that quantity, it is necessary that the wort should contain a certain proportion of saccharine matter. Accordingly, the wort must be at least of the strength $55\frac{1}{5}$ lbs. *per* barrel when it is let down into the fermenting tun, and the law prohibits it from being stronger than 75 lbs. *per* barrel. If we suppose the whole saccharine matter contained in the wort to be decomposed during the fermentation, 100 wine gallons would produce 14 gallons of spirits of the specific gravity 0.90917, provided the original strength of the wort was $55\frac{1}{5}$ lbs. *per* barrel. But this is a supposition which is never realized in practice. From a number of experiments, conducted with considerable care, we consider ourselves warranted in concluding, that, even when the fermentation is conducted with the greatest success, the quantity of saccharine matter, which will remain undecomposed in a barrel of wort of the original strength of $55\frac{1}{5}$ lbs. *per* barrel, cannot be less than 15 lbs. Hence a distiller can scarcely be expected to produce 14 gallons of spirits of the specific gravity 0.90917 from 100 gallons of wort, unless the original strength of his wort was at least $70\frac{1}{5}$ lbs. *per* barrel. In general, indeed, a still greater strength than this will be requisite. Now, to produce wort of the strength $70\frac{1}{5}$ lbs. *per* barrel from raw grain, without boiling, is by no means an easy task. Formerly when the product necessary was 19 gallons of spirits from the 100 of wort, the distillers were accustomed to give their wort the requisite strength by the process which they termed *lobbing*. This consisted in making up a very strong infusion of saccharine matter from malt, raw grain, &c. and adding it to the wort till it acquired the requisite strength. This substance was likewise called *bub;* and every distiller had his own method of preparing it. Probably sugar, treacle, or other similar prohibited articles, often found their way into it. It was on this supposition that the addition of it to wort was entirely prohibited in the late act of Parliament regarding the Scotch distilleries. And it was to prevent the secreting of the surplus spirits which might be produced above the 14 *per cent.* that the strength of the worts was limited to the maximum 75 lbs. *per* barrel.

When the quantities of grain, malt, and water, above indicated, are employed, the first worts drawn off will be about the strength of 73 lbs. *per* barrel, and the second worts of the strength 50 lbs *per* barrel; and the two, when mixed together, would constitute a wort of the strength of about 62 lbs. *per* barrel. Of course, the worts actually made by the Scotch distillers must exceed the strength of those which we have employed by way of illustration, by about eight lbs. *per* barrel. But we have reason to believe, that 62 lbs. *per* barrel would be a better strength than that pitched upon by those who contrived the act of Parliament by which the Scotch distilleries are regulated. Wort of such strength should yield about

* Still more lately, an act of Parliament has passed, reducing the product of spirits to 13 gallons from the 100 gallons of wash, and the strength of the wort must not exceed 70 lbs. of saccharine matter *per* barrel. The excise regulations bind down the distiller to a particular mode of operating. All such restrictions are very injurious to the improvement of the process. How far they may have been provoked by the attempts of the manufacturer to evade the excise duties, we pretend not to say.

12 *per cent.* of spirits, of the strength one to ten over proof, or of the specific gravity 0.90917. The original strength of the wort from which Dutch Hollands is made is considerably less than this, and we believe that nobody will deny that the Dutch spirit is, in general, much preferable to the whisky manufactured in the lowlands of Scotland.

The whisky made by smugglers in Scotland is universally preferred by the inhabitants, and is purchased at a higher price, under the name of Highland whisky. This is partly owing to its being made entirely from malt; but the chief reason is, that, from the unfavourable circumstances under which they operate, their wort is necessarily much weaker than the wort of the legal distillers. Probably it is not much stronger at an average than the wort of the Dutch Hollands. It has been generally conceived that the superiority of the illicitly distilled, or Highland whisky, as it is called, is owing to the mode of distillation. The smugglers distil in a much slower way than the legal distillers. But nothing can be more absurd than this opinion. The flavour of the spirits depends entirely upon the previous steps of the process. The slowness or rapidity of the distillation can make no difference whatever in the flavour, provided it be properly performed. Accordingly, we have seen spirits distilled by the very rapid mode of distillation that formerly was practised in Scotland, possessed of all the flavour of the best Highland whisky.

Great pains have been taken to put an end to the practice of illicit distillation in Scotland; but hitherto this very desirable object has not been gained. The smugglers have set the whole force of government at defiance, and have carried on their processes in spite of all the attempts that have been made to stop them. Many of them, indeed, have been brought to absolute ruin, and few of them, we believe, have ever been able to realize much money or to rise to independence. But still a new race of smugglers has risen up after another to carry on their illicit trade, to the great detriment of the revenue, and to an equal deterioration of the morals of the common people. Government do not seem to have been aware of the principal reason of the continuance of this evil. They have bound down the legal distillers in such a manner by injurious restrictions, that it is not in their power to produce a spirit equal in flavour to that manufactured by the smugglers, who lie under none of those restrictions which bind down the ingenuity of the legal trader. This superiority induces a corresponding desire in the inhabitants of Scotland to possess themselves of smuggled whisky, even at a higher price than that for which they can purchase the same article from the licensed distillers. The smugglers, in consequence, are winked at, or rather encouraged, by a very considerable proportion of the inhabitants of the country. While this feeling exists, we may venture to predict, that it will be impossible to put an end to smuggling in Scotland. But were government to remove the restrictions by which the Scotch distillers are at present bound; were they to allow them to make their wort as weak or as strong as they please, the consequence would be, that they would have it in their power to produce a spirit superior in flavour to the smuggled whisky. The high reputation of smuggled whisky would gradually be lost; the inhabitants of Scotland would lose their partiality for it; they would cease to purchase it except at an inferior price; and all the respectable part of the community would cease to purchase it at all. It would be impossible for smuggling to maintain itself under such disadvantages. Hence it is obvious, that, in a few years, it would no longer be practised.

The only reason that we can perceive for continuing the restrictions under which the distillers are at present placed, is the allegation that they are necessary in order to ensure the payment of the duty upon the spirits actually distilled. But we conceive that this duty might be levied with as much accuracy as at present, though all the restrictions on the strength of the wort were removed. From a number of experiments conducted upon a large scale, we conclude, that the fermentation, however successful, is capable of decomposing only four-fifths of the whole saccharine matter contained in the wort. Farther, we find, that for every pound of saccharine matter decomposed by the fermentation, there is formed half a pound of alcohol of the specific gravity 0.825. Now, every gallon of spirits of the specific gravity 0.90917, or one to ten over proof, contains 4.6 lbs. of alcohol, of the specific gravity 0.825. To form a gallon of spirits, then, of the specific gravity 0.90917, there is required the decomposition of 9.2 lbs. of saccharine matter. But as only four-fifths of the saccharine matter present are decomposed, we must increase 9.2 by a fifth, which will raise it to $11\frac{1}{2}$ lbs. The rule, therefore, for levying the duty on the distillers would be this. Ascertain, by the saccharometer, the strength of the wort, or the number of pounds avoirdupois of saccharine matter which it contains, and for every $11\frac{1}{2}$ of these pounds, charge the duty upon one gallon of spirits. This would be no hardship upon the distiller. If he is unable to produce a gallon of spirits from $11\frac{1}{2}$ lbs. of saccharine matter, he is not sufficiently acquainted with his business, and the necessity of paying the duty would stimulate his ingenuity to acquire the requisite information. He would soon discover two facts which would probably regulate his conduct; namely, that the flavour, and consequently the value, of his spirits increases as he diminishes the strength of his wort, and that the produce of spirits from the same quantity of grain increases also as he diminishes the strength of his wort.

It would be difficult, according to the method at present followed by the distillers, for the excisemen to determine the strength of the worts with the requisite degree of accuracy; but it would be easy, we conceive, to order matters so, that this information might be gained without in the least injuring the process of fermentation, to which these worts are to be subjected.

Some distillers, not satisfied with three mashes, which they think insufficient to exhaust the grains of all the matter that may be useful in the formation of spirits, add a fourth quantity of boiling water, after

the worts of the third mash are drawn off, and mash a fourth time. The worts of this fourth mash are always kept to be employed instead of pure water during next day's brewing.

II. *The Cooling.*

Wort from raw grain has a much greater tendency to run into acidity than wort from malt. On that account, the distillers endeavour to bring it down to the temperature requisite to begin fermentation as speedily as possible. As soon as the first worts have begun to run into the underback, they are made to pass into the coolers. The nature and disposition of the coolers vary so much, according to the size of the distillery, that a general description will by no means apply to them all. When the manufactory is of a moderate size, the coolers are a shallow wooden vessel, covering the floor of an apartment or suite of apartments, placed usually in the upper part of the distillery, and open as much as possible to the influence of the external air. Here the hot worts are pumped up, and left at a depth of one, two, or three inches, till they have acquired the requisite temperature.

When the distillery is on a large scale, it is usual to accelerate the cooling of the worts by agitation. Of late years a new contrivance has been fallen on, which answers much better than the old method, by bringing the worts almost instantly to the particular temperature which the distiller wishes them to acquire. This method is to pass the hot worts through a certain length of tin pipe, which is immersed in a running stream of water. By properly regulating the length of the pipe, the worts may be cooled down either to the temperature of the surrounding water, or to any other intermediate temperature required. As the worts in this case are cooled in close vessels, no evaporation goes on during the process. Hence their strength will not increase during the process, and the quantity will be precisely the same as in the underback, making allowance for the change of temperature. This probably would be a disadvantage to the distillers, while the present law obliges them to brew worts of a given strength. But if this restriction were removed, it would be rather an advantageous circumstance, because it would enable them to regulate the strength of their worts at pleasure, by the quantity of water employed during the mashing and infusion. To the excise-officer it would also be a convenient circumstance, because it would afford an additional security for determining the strength with accuracy. He would have it in his power to try the strength of the worts while hot in the underback, and when newly let down into the fermenting tuns, before the yeast was added. This second trial ought to give nearly the same result as the first. We say nearly, because, when the worts are hot, it is not so easy to determine their strength with accuracy, as when they are cold.

During the cooling of the wort from raw grain, there is always a considerable deposite of flocky matter, which we conceive consists chiefly, if not entirely, of starch. This flocky matter is swept along with the wort into the fermenting tun. It is the opinion of distillers, that it contributes materially to the formation of spirits during the fermentation. We have little doubt that the opinion is well founded. Probably during the fermentation it is converted first into saccharine matter, and then afterwards decomposed into alcohol and carbonic acid.

The temperature to which the wort is cooled, before it is let down into the fermenting tuns, differs a good deal in different distilleries, and even in the same distillery at different seasons of the year. Winter is the usual season for the distilleries, and it is the season which is considered as most advantageous for conducting the fermentation with success; for it is easy to raise the temperature of the fermenting room, to the degree which is considered as best adapted for the process. But when the weather is hotter than that degree, it is a much more difficult matter to keep the fermenting room sufficiently cool. In winter the distillers usually let down the first worts at about 70°; the second worts are cooled down to 60° or 65°. We do not perceive any good reason for this distinction: though we have frequently seen it practised.

III. *The Fermentation.*

This is by far the most important part of the whole process. It is by the skill and success with which it is conducted, that distillers excel each other. Upon it the profit and loss of the manufactory chiefly turn. Much pains have been bestowed in investigating it; but it is of so capricious a nature as occasionally to thwart the most skilful and experienced brewers. We shall describe the method of proceeding in this process usually followed by the Scotch distillers. In the article BREWING in this *Supplement*, we stated the facts at present known respecting the saccharine matter of the wort and yeast of beer which is employed as a ferment. To that article, therefore, we refer those who wish for information on these subjects.

The yeast employed by the Scottish distillers is chiefly brought from the London porter breweries. Small quantities may be occasionally obtained from breweries in their neighbourhood; but never we believe a sufficient quantity to answer their purposes. The best yeast is that which is thrown off the top of the porter during its fermentation. But what is sold by the porter brewers consists chiefly of the slimy matter which remains at the bottom of the vessels, when the clear porter is drawn off. Fresh yeast is better than stale; but the distillers being unable to procure a sufficient quantity of fresh yeast for their purposes, are under the necessity of using both fresh and stale.

The quantity of yeast employed depending upon its quality, it is impossible to lay down any very precise rules upon the subject. For the quantity of wort, which we have supposed in the preceding part of this article, a Scotch distiller would probably employ about twenty-seven gallons of good yeast, and about thirty-six gallons if he considered the yeast of inferior quality. Only a portion of this yeast is mixed at first with the wort. The remainder is generally added on the second, third, and fourth day. Most commonly, indeed, the whole is added on the third day. But it is customary to make a farther

addition at a latter period, if the brewer is of opinion that the fermentation is not proceeding so well as it ought to do. We have seen yeast added on the sixth day of the fermentation.

The first portion of yeast mixed with the wort is always, if possible, fresh yeast, and it is a great object with the distiller to have it of as good a quality as possible. For our wort the quantity of yeast first used may amount to nine gallons. On the second day nine gallons more may be added, and on the third day nine or eighteen gallons, according to its quality. Some distillers add nine gallons the first day, and twenty-seven the third. Some add nine gallons every day for four days. In short, there is considerable difference, and probably a good deal of caprice in the practice followed in the various manufactories At least we have never been able to obtain a satisfactory reason from any brewer, why he followed one practice rather than another. In hot weather we should prefer the addition of nine gallons of yeast every day for four days. But in cold weather it would probably answer better to add the whole yeast at twice; and perhaps the third day is the most proper for making the great addition.

The fermentation lasts 9, 10, 11, or 12 days, according to circumstances. Sometimes, though seldom, we have seen it last 13 days. During the first five days, the fermenting tuns are left open on the top, or only slightly covered. But, on the sixth day, they are shut up as closely as possible, so as to render the escape of the carbonic acid rather difficult. Two reasons have been alleged for this proceeding. 1. The carbonic acid gas is conceived to carry with it a portion of the alcohol, and by binding down the top it is supposed that the loss by this drain will be diminished. We do not lay much stress on this reason. The fermentation is almost at an end before the tuns are shut down. Of course, almost the whole of the alcohol abstracted by the carbonic acid has been already removed. 2. The presence of carbonic acid is conceived to promote the fermentation. Hence it is supposed that, by preventing that gas from escaping with facility, the attenuation will be greater than it otherwise would be. Perhaps there may be some foundation for this opinion. There is no doubt that carbonic acid gas may be substituted for yeast as a ferment; and that the fermentation of the wort, under such circumstances, will go on pretty well. We have seen the experiment tried by mixing yeast with wort in a close barrel, from which there proceeded a tin pipe that passed through another barrel filled with wort, and opened at the bottom of it. The gas was absorbed by the wort in this second barrel, and the wort was fermented by it. But the fermentation, as might have been expected, was not so complete as if it had been produced by the usual addition of yeast. The distillers do not collect any yeast from their fermenting vats, but beat it all into the liquid, being of opinion that any such collection would render the fermentation less complete; and, of course, diminish the proportion of spirits obtained.

The wort most commonly increases in temperature from 20° to 25° degrees of the thermometer. Supposing it let down into the fermenting tun at 57°, its temperature, when at the highest, may amount to from 78° to 82°. It usually acquires the highest temperature on the fourth day of the fermentation, frequently upon the fifth day: sometimes upon the sixth, the third, or the seventh day; and we have seen it as late as the eighth, or even the eleventh day, before its temperature became a maximum.

The following table exhibits the number of cases on which the highest temperature took place in these respective days in seventy-six brewings, conducted upon a pretty large scale:

4th day,	-	-	31 times.
5th day,	-	-	23
6th day,	-	-	9
3d day,	-	-	6
7th day,	-	-	5
8th day,	-	-	1
11th day,	-	-	1

This diversity, no doubt, depends upon the goodness of the yeast employed. And, as we have no good criterion by which to determine the exact value of yeast as a ferment, it is impossible to be able to foretell the exact result in any particular case. Indeed, we consider the uncertainty of the value of yeast as the great difficulty which the distiller has to encounter. Any person who could discover a method of estimating the exact value of any particular yeast as a ferment would greatly improve this difficult manufactory. We do not believe that such a discovery is impossible. Perhaps the specific gravity of the yeast, or the quantity of solid matter which is left behind when a given weight of the yeast is evaporated to dryness, might furnish very material information. We are rather surprised that no distiller has thought of subjecting yeast to a series of experiments, with a view to ascertain its real value as a ferment. The new information which he would acquire would more than compensate for the trouble, and would probably give him the means of improving his manufactory, or, at least, of forming some notion of the value of the yeast which he purchases.

As the fermentation proceeds, the specific gravity of the wort diminishes, owing to the decomposition of the saccharine matter, and its conversion into alcohol and carbonic acid. This diminution of specific gravity is called *attenuation* by distillers, and is employed by them as the measure of the success of the fermentation. They can easily foretell the quantity of spirits which their *wash* (the name by which their fermented wort is distinguished) will yield, if they know the attenuation which has taken place during the fermentation. This diminution of specific gravity is produced by two causes. 1 The destruction of the saccharine matter previously dissolved in the liquid, and which occasioned its specific gravity to be greater than that of water. If the whole of this saccharine matter were decomposed, it is obvious that the change of specific gravity from this cause would be exactly such as would sink the wash to the specific gravity of water. 2. The second cause of the diminished specific gravity of the fermented wort is the formation of a quantity of alcohol, which, being

lighter than water, occasions, by its evolution, a corresponding diminution of the specific gravity of the liquid. The specific gravity of the purest alcohol, which it has been hitherto possible to obtain, is 0.796 at the temperature of 60°. When mixed with water, it enters into a chemical combination with that liquid. Hence the specific gravity is greater than the mean of that of the water and alcohol; though considerably less than that of water. It is obvious, if we were to add alcohol to the unfermented wort, we would diminish its specific gravity. We might even, by this means, render it as light, or even lighter, than water, though none of the saccharine matter were destroyed. It is obviously impossible, therefore, to determine how much saccharine matter has been decomposed by the fermentation from the attenuation alone. Suppose the original specific gravity of the wort to have been 1.060; and suppose that, after the fermentation, its specific gravity is reduced to 1.002. The first of these specific gravities indicates 55.8 lbs. of saccharine matter *per* barrel; the second 1.6 lbs. *per* barrel. It does not follow, as the distillers suppose, that 54.2 lbs. of saccharine matter *per* barrel have been decomposed, and converted into alcohol and carbonic acid. A considerable portion of the saccharine matter still remains undecomposed; but the alcohol which has been formed, counteracts the specific gravity of this saccharine matter, and prevents its presence from being correctly indicated by the saccharometer. But if we measure out a quantity of such wash, put it into a retort or still, and distil off about a third of it; if we then take the residual wash which remains in the retort or still, and add pure water to it till its original bulk be restored, the saccharometer being applied to it will indicate the quantity of saccharine matter which it still contains. And this quantity being subtracted from the original quantity of saccharine matter contained in the wort before the fermentation commenced, the remainder will be the saccharine matter decomposed by the process.

Alcohol is a substance which has a tendency to stop fermentation, and it stops that process completely, when added to fermenting wort in sufficient quantity. It must be obvious from this, that very strong worts are injurious to the profits of the distiller. Because the stronger the wort the greater will be the proportion of alcohol evolved, and, of course, the fermentation will ultimately be impeded or stopped altogether, before the whole saccharine matter is decomposed. Accordingly, the *spent wash* will always be found to contain a considerable proportion of saccharine matter, and it might be fermented again, and made to yield no inconsiderable quantity of spirit. The writer of this article made nine trials with malt worts, which were designedly made weak. They were fermented as thoroughly as possible, and the following table indicates the specific gravities to which they were reduced. The original specific gravity probably did not much exceed 1.045.

	Sp. Gravity.
1.	1.0012
2.	1.0045
3.	1.0018
4.	1.0000
5.	1.0012
6.	1.0045
7.	1.0047
8.	1.0007
9.	1.0007

Upon examining the state of the wash after the fermentation was at an end, we found that 4.34 parts of the saccharine matter had been decomposed, and that 1 part remained unaltered. So that in these nine experiments, which were as favourable as possible to the fermentation, on account of the weakness of the worts, not much less than one-fifth of the whole saccharine matter remained unaltered. Surely, then, we may lay it down as a fact, that, in all cases of fermentation in a Scotch distillery, at least one-fifth of the whole saccharine matter is prevented from being decomposed by the antifermenting power of the alcohol evolved. The consideration of this circumstance renders it of more importance to allow the distiller to make his wort weak. For the weaker the original wort the less will the quantity be of the saccharine matter, which is prevented from being decomposed by the presence of the alcohol evolved.

When the heat has acquired its maximum, we may reckon, at an average, that nine-tenths of the whole attenuation has been completed. No judgment can be formed of the ultimate attenuation, by the rapidity or slowness with which the heat reaches its maximum. We have seen the attenuation equally good, when the maximum temperature happened on the third, fourth, fifth, or sixth day.

It is impossible to lay down any specific rule with respect to the length that attenuation ought to be carried. The object of the distiller is to render his wash, if possible at least, as light as water. This object they frequently accomplish. But it sometimes happens, that the fermentation stops when the specific gravity has sunk to 1.013 or 1.008, and no addition of yeast will make it sink lower. Bad yeast is the most probable reason of this ill success. If the wash be allowed to remain in the fermenting tuns after the fermentation is at an end, its specific gravity will be found gradually to increase a little, and it will not yield so great a proportion of spirits. This is owing to the formation of vinegar in the wash, which takes place at the expence of the alcohol; and if the vinegar forming process were allowed to go on long enough, the alcohol would disappear altogether.

Distillers always ferment their worts in tuns of a large size. This is attended with the advantage, that the artificial heat evolved by the fermentation is not so speedily dissipated as it would be, if the process were conducted in small vessels. Some distillers fill the tuns only partly, leaving a portion of the upper part empty, that it may contain the froth formed when the wort is in full fermentation. Others fill the tuns almost to the top, and cover down the mouth with a lid, from which a tube passes to an open vessel placed above the tun. When the liquid swells by the fermentation, it passes up the

tube into the open vessel, and runs down again when the fermenting process subsides. No regular set of experiments, that we know of, has been made to determine which of these two methods is the best.

We have already observed, that every 9.2 lbs. of saccharine matter really decomposed by the fermenting process, yield a gallon of spirits 1 to 10 over hydrometer proof, or of the specific gravity 0.90917 (at the temperature of 60°). But as the distillers are not in possession of a good method of determining how much saccharine matter has been decomposed, the easiest rule will be to allow 11½ lbs. of saccharine matter, estimated before the fermentation begins, to yield a gallon of spirits at 0.90917 specific gravity. If the original worts be very weak, perhaps we might take 11 lbs. of saccharine matter as producing that quantity of spirits. But while the present law respecting the strength of the worts continues, 11½ lbs. will be found, upon an average, to come very near the truth.

It does not seem to be possible to ferment wort from a mixture of raw grain and malt as completely as is required for the purposes of the distiller, without its becoming sour. There seems no reason to doubt that the acid formed is the acetic. Some are of opinion, that the presence of this acid contributes to improve the flavour of the spirits. But the quantity of acetic acid usually present in wash is so small, that we do not see any reason for supposing that it can produce any sensible effect. It is important, therefore, that the acidity should be as small as possible, because the acid is formed at the expence of the alcohol in the wash. Hence the wash ought to be distilled as soon as the fermentation has come to a conclusion.

IV. *The Distilling.*

The stills commonly used in other countries are of large dimension, and very deep, so that a great deal of time is necessary to finish one process. Once in the week, for example, is no uncommon period. The same kind of still was used in Scotland till about the year 1787, when the duty began to be levied on the distillers by a licence paid at the commencement of the season, upon every still according to its capacity. This was done to prevent that propensity to smuggling by which the generality of Scotch distillers were supposed to be actuated. The quantity of spirits which a still of given dimensions could produce in a year was calculated, and the licence was laid on according to it. This saved the excise-officers all farther trouble after gauging the stills and collecting the licence-duty, excepting an occasional visit to be certain that no new still of larger dimensions was substituted for the old one. But about the year 1788, Messrs John and William Sligo, at that time rectifiers in Leith, made an important alteration in the shape of the still, at the suggestion of an Englishman, which greatly increased the rapidity of distillation. They diminished their height, and increased the diameter of their bottom. The consequence of this alteration was, that they were able to distil off the contents of the still in a few hours, instead of once a week, as had formerly been the practice. Thus they were enabled to produce a great quantity of spirits from a very small still, and, of course, paid in reality a much smaller duty than their brother manufacturers. This lucrative improvement they possessed exclusively for about a year; but a secret of such importance could not be long confined to a single house. It became gradually known to other distillers, and was soon imitated by all. The licence-duty was increased year after year; but the ingenuity of the distillers enabled them to outstrip the acts of Parliament; till, at last, a committee of the House of Commons was appointed to investigate the subject in 1799. A very bulky report was published by this committee, which contains a vast collection of curious facts respecting the mode of distillation at that time practised in Scotland. The licence, in consequence of this report, was laid on the distiller, on the supposition that he could discharge his still every eight minutes, during the whole season that the manufactory was in activity. Since that time the time of discharging the still was considerably shortened. But the saving in point of time was attended with such an enormous waste of fuel, that it is rather doubtful whether it was attended with much additional profit to the distiller. In the year 1815, which was the last year of the licence-duty, a still capable of holding 80 gallons could be completely distilled off, emptied, and ready for a new operation, in 3½ minutes, or even, it is said, in some cases in 3 minutes; and a still of 40 gallons in 2½ minutes. At that time a change took place in the Excise laws; the licence-duty was abolished, and the whole duty was levied, as in England, on the wash and the spirits produced. There was, of course, no longer any necessity for continuing the rapid mode of distillation; and, as it was attended with a very considerable waste of fuel, and was in other respects much more expensive than the slow process, it has been, of course, discontinued. We conceive, however, that it will be worth while to give a short description of the still and furnace which the Scotch distillers employed during the existence of the licence-duty. It would be a great pity, indeed, to allow the results of such a series of important experiments to be forgotten.

The stills were made of copper. Those capable of holding 44 gallons were about 44 inches in diameter at the bottom, and about 5 inches deep. Those capable of holding 80 gallons were 54 inches in diameter, and about 8 inches deep. The bottom was perfectly flat, and about three-eighths of an inch thick. Within it there were a number of iron chains, which were turned round by machinery, and rubbing against the bottom prevented the thick matter, which the wash always contains, from adhering to the bottom of the still and catching fire. This would have almost immediately occasioned the destruction of the still; and the scorched starchy matter would have communicated a disagreeable flavour to the spirits, which could not have been got rid of afterwards. There was likewise a circular plate in the inside of the still, towards its top. The use of it was to break the bubbles that rise during rapid distillation; and, of course, lessen the risk of the still boiling over, or

running foul, as the distillers term it; and, consequently, the distiller was enabled to put a greater charge of wash into the still than it would have been in his power to do if the plate had been omitted.

These stills were supported by resting an inch and a half on the brick-work, all round the bilge. The furnace was quite level, and was placed at the distance of 15 inches below the bottom of the still. The inner end of the grating-bars was placed 15 inches within a line falling vertically from the part of support of the bilge of the still. The bars were in two lengths; the inner length was 21 inches, the outer 30 inches, supported by a cross bar between them, four inches square. In front of the bars was a dumb-plate, 10 inches broad. The bottom of the ash-pit was three feet below the grating bars, and on a level with the floor of the distillery. The bars were two inches thick, three inches deep, and three-fourths of an inch apart. The brick-work extended 21 inches beyond the dumb-plate, and was four feet wide and four inches higher outside than at the bilge of the still. The furnace doors were 30 inches wide. The bottom of the furnace, beyond the grating-bars, was lined with fire-brick nine inches deep, and passed level backward into the chimney.

The chimney was 60 feet high, 4 feet square within, from top to bottom, and consisted of a double wall. The inner wall of fire-bricks was nine inches thick. The outer wall was placed at three inches distance, on all sides, from the inner wall, and the space was left open at the top. The outer wall was 18 inches thick at bottom, diminishing regularly on the outside, till reduced to nine inches at top. The two walls were tied together, at certain distances, by long fire-bricks. This separation of the two walls was found to prevent the rapid destruction of the chimney from the intensity of the fire, which always happened when the two walls were in contact.

Such was the construction of the furnace, and the shape of the stills, during the time that rapid distillation was practised in Scotland, when both had been brought to the greatest degree of perfection which the distillers were capable of giving them. The writer of this article has not had an opportunity of seeing the shape of the stills used by the Scotch distillers, since the licence-duty was abolished. But it is probable that the old shape will not have been entirely restored; but that the present stills, though much larger in size, imitate the late stills in the great diameter of their bottom, and their comparative shortness when compared with the stills employed by the English distillers.

The top of the still ends in a kind of tube, which is bent downwards, and connected with a tin-tube, which makes a number of revolutions in a large vessel filled with cold water, and therefore called the worm. This large vessel is called the *refrigeratory*, and care is taken to keep the water in it always cool by means of a stream of water, which is constantly flowing into it. The wash being put into the still, and the top being fixed down, heat is applied to the vessel till it is made to boil. The spirits being more volatile than the water, pass over first in the state of steam, and are condensed into a liquid as they pass through the worm. The first portions that come over are very strong; but the strength diminishes as the process proceeds. The distiller continues the distillation till the liquid, which flows from the worm, is as heavy as water, or at least so nearly so that the quantity of spirits remaining is not considered as a compensation for continuing the process any longer. The strength of the liquid proceeding from the worm is ascertained by a small hydrometer, with which it is tried every now and then; and whenever a certain mark on the instrument comes to coincide with the surface of the liquid, a cock at the bottom of the still is opened, and what remains in the still is let off. This liquor is called the *spent wash*. It is a muddy brown liquid, still containing a quantity of undecomposed saccharine matter. It is therefore used as food for cattle. These animals are fond of it, and soon fatten upon it.

To prevent the still from boiling over, which is apt to happen towards the commencement of the distillation, it is usual to throw a piece of soap into the vessel along with the wash. This substance is partly decomposed, and the oily matter which it contains spreading on the surface forms a thin coat, which breaks the large bubbles when they reach it, and thus prevents the wash from swelling beyond the requisite bulk. Butter would answer equally well with soap, and would be less apt to give a disagreeable flavour to the spirits; but its high price prevents the possibility of using it for that purpose. We have some suspicion that hogs' lard would answer. If it were found to do so, it would be cheaper than soap, and less apt to give a bad flavour to the spirits. The supposition, however, that soap communicates a disagreeable flavour to spirits, though very generally entertained, is, we believe, a mistake. We have certainly met with spirits distinctly tainted with soap, and having in consequence a highly nauseous taste. But this was at a time when the rapid mode of distilling was only on its progress to perfection, and was owing, we believe, to little bits of the soap having been accidentally forced into the worm, and afterwards dissolved by the spirits.

It is impossible to lay down any rule with respect to the strength of the weak spirit obtained by this first distillation, and which is called *low wines* in Scotland. That strength must depend partly upon the original strength of the wort, partly on the attenuation which has taken place during the fermentation; but chiefly upon the attention of the distiller to distil off the whole of the spirituous portion of the wash. In a great number of cases in which we have had the curiosity to determine the strength of the low wines in distilleries, we have found their specific gravity at 60°, differing but little from 0.978; frequently a little weaker, and very rarely a little stronger. Low wines of this strength contain the fifth part of their weight of alcohol of the specific gravity 0.825; the remaining four-fifths are water.

The low wines are put into the still and subjected to a second distillation, which in Scotland is called *doubling*. The first portion which comes over is a milky liquid, known by the name of *foreshot*. Its taste is disagreeable, and on that account it is received by itself, and returned back into the low wines to be subjected to another distillation. The properties of the foreshot are owing to an oil with which

it is loaded. When the spirits begin to run transparent from the end of the worm, they are allowed to run into a receiver prepared for them. Whenever their specific gravity, determined by the hydrometer, has reached a certain point, they are no longer allowed to flow into the receiver containing the spirits, but into a place by themselves, and the distillation is continued till the liquid coming over has approached very nearly to the specific gravity of water. This third portion is called *faints*. It is mixed with the low wines and distilled again. Thus the distillation of the low wines is continued, till the whole of their alcoholic part is brought to that degree of strength which fits them for the market. The strength at which the duty is levied on them is 1 to 10 above hydrometer proof, which corresponds with the specific gravity 0.90917. They are prohibited from sending out of their manufactory spirits of greater strength than this, or of a strength under 1 in 6 below proof, or of the specific gravity 0.9385. Between these two intervals the specific gravity of their spirits may be considered as vibrating. For it is not to be expected that they should be able always to produce spirits of exactly the same specific gravity. We have found the spirits, as obtained by doubling, of a specific gravity as low as 0.908, and as high as 0.925. No doubt they might be obtained much stronger or much weaker than these two extremes, if there were any object in view, to induce the distiller to alter his usual practice.

Such is the mode followed in Scotland for obtaining whisky. The distillers are at pains to purchase the best English barley which they can procure. They are certainly in the right to select English barley for malting; for English barley, when malted, yields more spirits than in the state of raw grain. But for that portion of grain which they use in the distilleries without malting, it would be their interest to employ the best big which they can procure. For good big, while in the state of raw grain, yields rather more spirits than an equal quantity of the best English barley. And as it can be purchased at a cheaper rate than barley, it could obviously be employed with economy, as a substitute for that grain. Big is greatly deteriorated by malting it; of course it would be improper to employ it in distilleries, in that way. But the distillers might employ it in the state of raw grain with great advantage.

Chap. II.—Of the Mode of Manufacturing other Kinds of Spirits.

In this chapter we shall merely make a few very short observations on the processes followed by the distillers in other countries.

1. *Dutch Geneva.*

The Dutch have long been famous for the manufacture of an excellent kind of spirits, known in Scotland by the name of *Gin*, in England by the name of *Hollands*, and sometimes by the name of *Geneva*. We have been told, that the manufacture of it originated in the city of Geneva; and that this was the origin of the name Geneva, still applied to it in commerce. But we have no means of determining how far this statement may be depended on. We have not seen in print any accurate account of the mode of making Geneva, practised by the Dutch. But the following account may, we believe, be relied on. We are indebted for it to a friend, who, about forty years ago, went over to Holland, on purpose to make himself acquainted with the process. His object was to establish a similar manufactory in Scotland. But the severe laws, by which the Scotch distillers were soon after bound, put it out of his power to execute his plan.

112 Pounds of barley malt, and 228 lbs. of rye-meal, are mashed together, with 460 gallons of water, of the temperature 162°. After the infusion has stood a sufficient time, cold water is added till the strength of the wort is reduced to 45 lbs. *per* barrel. The whole is then put into a fermenting back, at the temperature of 80°. The vessel is capable of holding about 500 gallons. Half a gallon of yeast is added. The temperature rises to 90°, and the fermentation is over in 48 hours. The attenuation is such, that the strength of the wash is not reduced lower than 12 or 15 lbs. *per* barrel. The wash is put into the still, with the grains and all. The low wines, as usual, are distilled again, and the spirits of the second distillation are rectified. So that the Hollands pass thrice through the still. A few juniper berries and some hops are used to communicate a peculiar flavour to the spirits.

Now, 45 lbs. *per* barrel constitute a wort so weak, that it will not yield above seven and a half *per cent.* of spirits of the usual strength. So that the produce which the Dutch obtain from their wort cannot amount to much more than half what the Scotch distillers are obliged to produce from theirs.

It is obvious, from the preceding account, that the fermentation is very imperfectly accomplished in the Dutch process. The small quantity of yeast employed, and the short time that the wort is allowed to ferment, necessarily imply imperfection in the fermentation. And this is obviously the case, for the original strength of 45 lbs. *per* barrel is only reduced to 15 lbs. *per* barrel. We have often seen the attenuation of the porter in the London breweries not much less complete. What advantage is gained by putting the grains into the still along with the wash, we have not the means of determining. Such a practice can only be followed in distilleries upon a very small scale. We do not see how it could be practised in the Scotch distilleries. Indeed, we have no doubt whatever, that when the mashing is repeated a sufficient number of times, and the grains sufficiently washed with hot water, every thing likely to contribute to the formation of spirits will be carried off.

Every person acquainted with the flavour of Hollands and Lowland whisky, must admit that the former is greatly superior to the latter. Indeed, the flavour of Hollands is equal to that of malt whisky. This is owing in part to the small proportion of raw grain used by the Dutch distillers. 112 lbs. of barley malt may be reckoned at three bushels. We do not know the average weight of a bushel of rye; but if we suppose it to be 50 lbs. 228 lbs. will amount to about $4\frac{1}{2}$ bushels. So that, in the Dutch distilleries, the malt bears to the raw grain the proportion of two to three. We suspect that another reason of the superiority of the Dutch spirit over the Scotch, is the small quantity of yeast employed by the manu-

facturers of Hollands. The vast quantity of porter yeast used by the Scotch distillers, often in a state almost approaching to putrefaction, cannot but have an injurious effect upon the flavour of their spirits, and has undoubtedly contributed to the superior reputation of Highland over Lowland whisky. For the Highland distillers (especially the smugglers) have not the means of procuring yeast from London. Of course, their wash is less perfectly fermented; but the flavour of their spirits is much more agreeable. We think, indeed, that the flavour communicated by the yeast to Scotch Lowland whisky may be distinctly perceived, and on that account are disposed to suspect that the flavour of the spirits always suffers in proportion as the fermentation is brought nearer a state of perfection. Any person who should find out a method of fermenting wort without the necessity of employing such quantities of porter yeast as the distillers use, would undoubtedly prodigiously improve the flavour of the spirits manufactured by the Scotch distillers. If government were to make such an alteration in the laws, as would enable the distiller to employ a greater proportion of malt without any material increase of expence, the object might be considered as accomplished. In the present state of the manufactures of Great Britain, it would be impossible to confer a greater favour on the country, than a thorough revisal of the excise laws, under the auspices of a set of individuals, at once intimately acquainted with the most improved state of chemical science, and with the most liberal principles of political economy. Every thing that improves the quality, and diminishes the price of our manufactures, is of more value to the country than our legislators seem to be aware of.

We do not think that Hollands could be manufactured in Great Britain with any probability of success. The experiment was tried at Maidstone, in Kent, by a Mr Bishop, who had interest enough with Mr Pitt to get a special clause introduced into an act of Parliament permitting him to manufacture Hollands according to the Dutch method. But the manufactory was never successful. The Maidstone Hollands never acquired much reputation. The distillery languished for some years, and then terminated in a bankruptcy. Some attempts have been lately made to revive the Maidstone establishment. But we may venture to predict that they will not be successful.

2. *Rum.*

This is the name given to a spirit manufactured in the West India Islands, from the molasses, &c. which remain after the sugar is separated in small crystals from the boiled juice of the sugar cane. We do not know any thing about the origin of the word *rum*, or the time at which the manufacture of this spirit commenced; not, probably, till after the West Indies were colonized by Europeans. At present it is chiefly in the islands belonging to Great Britain that this spirit is made. The process, as we obtained it from a Dominica planter, who had for many years been in the habit of making this spirit, is as follows:

Twelve parts of sweets are dissolved in 100 parts of water, and fermented as completely as possible by means of yeast, which is chiefly obtained in the distillery itself by means of the fermentation of the rum wort, which gradually generates it. Fourteen gallons of spirits, 1 to 10 over proof, are obtained from 100 gallons of wash. If this statement be correct, the produce of spirit from molasses exceeds considerably what can be obtained in this country from barley. A solution of 12 parts of sugar in 100 of water would make a wort containing about 44 lbs. of saccharine matter *per* barrel; from 100 gallons of which in this country we would not obtain more than 8 gallons of spirits of the above strength. But we suspect some mistake on the part of our informer, as he communicated the process to us in this country several years after he had given over the actual superintendence of his rum distillery.

The peculiar flavour, which distinguishes rum, and makes it so agreeable to the taste, is undoubtedly owing to a peculiar oil contained in the sugar cane. For when spirits are made in this country from sugar, they are entirely destitute of the peculiar flavour of rum, and resemble, in their properties, the common spirit made in this country from barley. The colour of rum is derived from the oak casks, in which it comes to this country from the islands in which it is made.

We shall say nothing respecting *brandy* and *arrack*, as we could add nothing material to what has been already said respecting these spirits in the *Encyclopædia*.

Chap. III.—On the Nature of the Vinous Fermentation.

In the article Brewing, of this *Supplement*, we have given a short sketch of the facts hitherto ascertained, respecting the nature of the change which saccharine matter undergoes when fermented; and we have very little to add to the facts stated in that article. We shall merely enter a little more minutely into the detail of facts, than we thought necessary under the article Brewing.

Common sugar has been analysed by Gay-Lussac and Thenard, by Berzelius, and by Dr Prout. The method followed by each differed a little from that of the others, and the results, though they do not quite tally, certainly approach considerably to each other. The following table exhibits the composition of 100 parts of sugar, according to each of these chemists:

	Gay-Lussac and Thenard.	Berzelius.	Prout.
Oxygen,	50.63	49.083	53.33
Carbon,	42.47	44.115	39.99
Hydrogen,	6.90	6.802	6.66
	100.00	100.000	99.99

To be able to determine from these analyses the number of atoms of oxygen, carbon, and hydrogen, which are requisite to form a constituent particle of sugar, it would be requisite, in the first place, to be able to specify the weight of sugar capable of neutralizing a given weight of any solifiable base. Berzelius found, that when a solution of a given weight of sugar in water, was digested over oxide of lead, the oxide was at first dissolved, but, after a certain

interval of time, a light white powder makes its appearance. This powder is a compound of sugar and oxide of lead, and is composed, according to Berzelius's analysis, of

Sugar,	41.74	10.03
Oxide of lead,	58.26	14
	100.00	

Now, the equivalent number for oxide of lead is 14. It follows, from this, that if the white powder be a compound of an atom of sugar and an atom of oxide of lead, the weight of an atom of sugar is 10. But we have no evidence whatever for adopting one atom of sugar in this compound rather than two. And as one atom will not accord with the phenomena of fermentation, it is better to consider the white powder as a compound of one atom oxide of lead and two atoms of sugar. On that supposition an atom of sugar will weigh about five. Now, if we suppose it to be composed of

3 atoms oxygen,	= 3.
3 atoms carbon,	= 2.25
3 atoms hydrogen,	= 0.375
	5.625

the weight of an atom of sugar will be 5.625, which does not differ very much from the weight as resulting from Berzelius's analysis; not more, indeed, than might be expected from the extreme difficulty of analysing such a compound with precision. But if we suppose the weight of an atom of sugar to be as now stated, 100 parts of it will be composed of

Oxygen,	= 53.31
Carbon,	= 40.03
Hydrogen,	= 6.66
	100.00

Now, as these numbers are almost exactly the same with those of Dr Prout, we are disposed to consider them as representing the true constituents of sugar.

From the phenomena of fermentation, as described under the present article, and in the article Brewing, it appears, that by the fermentation the sugar is decomposed and converted into alcohol and carbonic acid. Alcohol, according to the analysis of Theodore de Saussure, is composed of three atoms hydrogen, two atoms carbon, and one atom oxygen. Carbonic acid is composed of two atoms oxygen and one atom carbon. Hence the weight of an integrant particle of alcohol is 2.875. For

1 Atom oxygen	= 1
2 Atoms carbon	= 1.5
3 Atoms hydrogen	= 0.375
	2.875.

And an integrant particle of carbonic acid weighs 2.75.

We see likewise that a particle of sugar is capable of being decomposed into an integrant particle of alcohol, and an integrant particle of carbonic acid. For a particle of alcohol is

	Oxygen.	Carbon.	Hydrogen.
composed of	1 atom +	2 atoms +	3 atoms
Carbonic acid of	2	+ 1	+ 0
	3	+ 3	+ 3

Both together, we see, corresponding to the number of atoms in a particle of sugar.

If fermentation then be merely the separation of sugar into an atom of alcohol, and an atom of carbonic acid, there ought to be formed

Of alcohol	2.875
Of carbonic acid	2.75

But alcohol of 0.825 contains about the fifth of its weight of water. Hence, by fermentation, sugar is converted into

Alcohol of 0.825	3.45 parts or	55.6
Carbonic acid gas	2.75	44.4
	6.20	100.0

Now, these proportions approach very nearly the results obtained by Lavoisier and Thenard. We are disposed therefore to consider the explanation which we have given as likely to be the true one.

In what way the yeast acts, if no portion of it enter into the composition of the alcohol or carbonic acid, as would appear from what we know of the subject, we have no means at present of forming a conception. It would be requisite, before we could reason on the subject, to be better acquainted with the composition of yeast than we are at present. (J.)

DIVIDING, or Graduating Instruments.—See Ramsden's Machine, in the *Encyclopædia*.

DIVING. In the *Encyclopædia* we have given an account of several machines for diving, and a description of the diving-bells of Halley and Spalding. In the present article we have to notice an improved method of supplying air to a diving-bell, by means of a syringe or pump, which forces the air down in a continual stream into the bell, whence it escapes from beneath the lower edges of the bell, or from a waste pipe, as fast as it is supplied. In this way, the air is kept very pure, and the people in the bell have no kind of trouble to obtain a supply. Dr Halley's original method of lowering the air in casks required the attention of a person within the bell, to let out a portion of the heated air from the bell, and then to admit the fresh air contained in the cask.

We believe that Mr Smeaton was the first who put in practice the method to which we allude; though it had been frequently proposed by other inventors. His first attempt was in shallow water, the bell being only intended to enable workmen to examine and repair the foundations of a bridge, which had been laid by the caisson method. This was at Hexham in Northumberland, in 1786.

A few years afterwards, Mr Smeaton constructed another bell upon the same principle, for the works at Ramsgate harbour. It was used to raise up large stones, which had formerly been thrown into the sea around the base of the pier. When it was propo-

Diving.

sed to build an advanced pier, by means of caissons, these stones required to be cleared away, and the ordinary means were not found sufficiently expeditious.

The bell was made of cast-iron, in one piece, and of a sufficient weight to sink in water without any extra ballast. In the top were proper apertures with lenses, for the admission of light, and also a strong shackle for the chain by which the bell was suspended. A strong leathern hose, or pipe, was connected with the top of the bell, to convey air into it from an air-pump placed either in a boat or on the shore.

This kind of diving-bell has since been applied to the purposes of building foundations of masonry in deep water, under the direction of Mr Rennie, who has constructed machinery to move the bell under water in any direction. This acts with such facility, that the masons in the bell can make great dispatch in laying the stones. Plate LXX. contains drawings of the diving-bell and machine, planned by this eminent engineer, for the harbour of Houth near Dublin, and which was used with success in building the foundation walls for the pier at a considerable depth below water.

Fig. 1. is a section showing the machine, and the bell viewed in the direction of the length of the wall which is to be erected; and fig. 2. is an elevation of the same as it appears when viewed from the sea. A is the bell, which is made of cast iron. It is suspended by strong chains passed through eyes *rr* and through the ring *m* of a tackle B. FF figs. 1 and 2. are strong beams supported in an horizontal position by cross-beams G, resting at one end on the shore, and the other ends supported by a scaffolding L of piles firmly braced. On the beams F two iron railways are laid for the wheels of two carriages to run upon; one of these carriages contains the tackle which suspends the bell, and the other has a similar tackle to hoist the large stones which are to be laid on the wall X. Each carriage runs with four wheels *a a* upon the railways F, and has a smaller or upper carriage running upon it in a transverse direction; and this upper carriage contains the windlass purchase tackle, by which the bell or the stone is raised. Thus E is the timber frame of the principal carriage, on the top of which are railways for the wheels *dd* of the upper carriage, of which D is the frame; and C is the roller or barrel to wind up the rope or fall of the great purchase tackle B, which is suspended from the frame of the carriage, and bears the weight of the bell. On the end of the barrel is a large cog-wheel M which is turned round by a pinion fixed on the axis N, of a second wheel O, and this is turned by a pinion, to which the handles H are applied. By turning these, two men can raise or lower the bell with ease. In order to move the bell in either direction, the wheels *aa* of the lower carriage E are provided with cogs at one edge, and pinions *b* work in the teeth of these; both pinions *b* are fixed on the same axis, which extends across the frame; and wheels *c* are also fixed on each extremity of the axis. These wheels have holes or mortices in them to receive handspikes or levers, by which they can be turned round, and will then move the lower

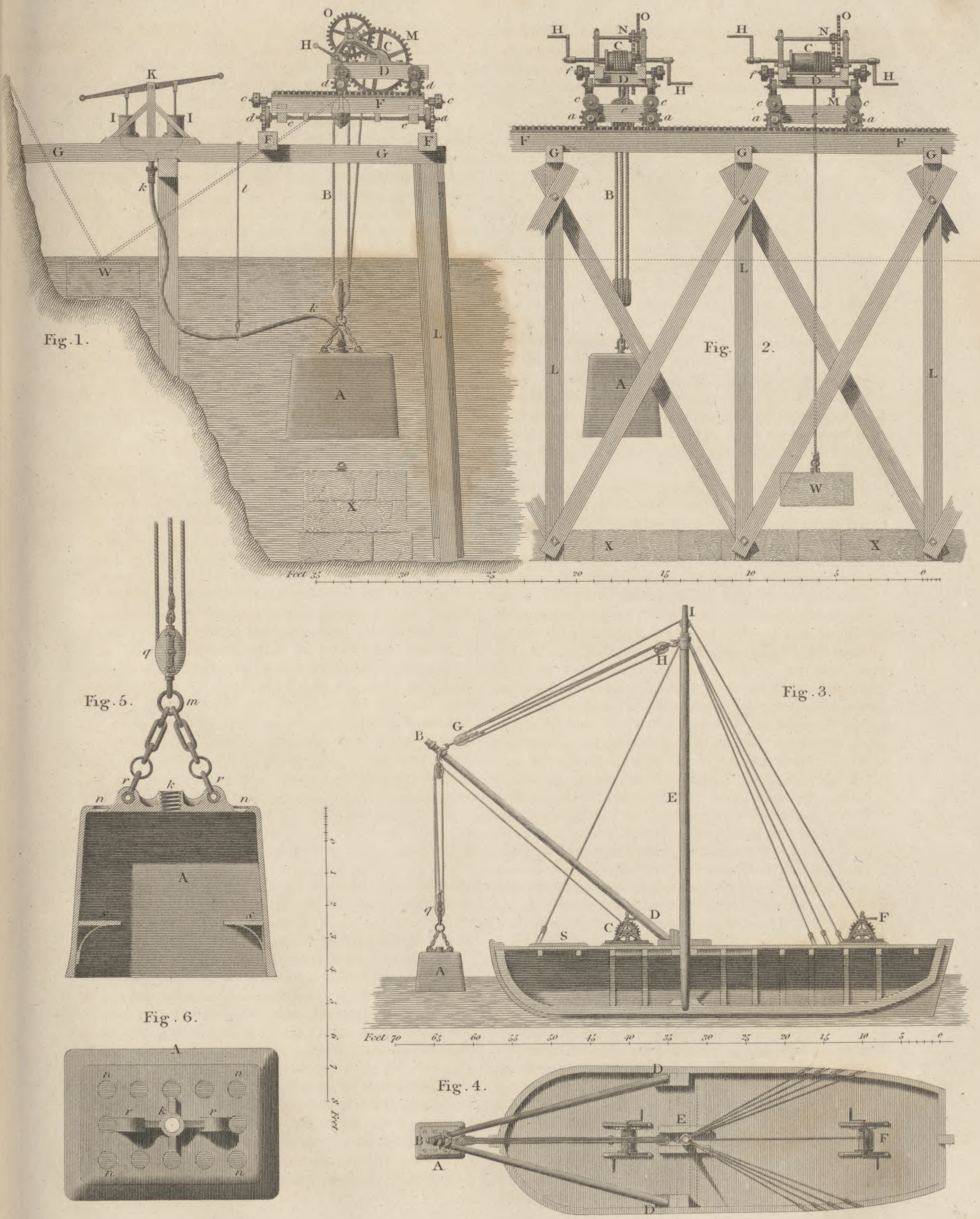
Diving.

carriage, and the bell along the railways FF, in the direction of the length of the wall, which is to be built as shown by X. In like manner, the wheels *dd* of the upper carriage are provided with cogs and pinions *e*, on the end of which are the capstan head *f* to receive handspikes, when it is required to move the upper carriage and the bell in a transverse direction. By means of these two motions in transverse directions, the bell or the stone can be suspended over any required spot in the wall, and lowered down thereupon as the men in the bell direct. Fig. 5. is a section of the bell, and fig. 6. a plan to show the apertures *nn* for the lenses which give light. Two men descend together, a seat *s* being fixed across on each side of the bell. The air pipe is screwed on at *k*, and proceeds to the air pump as shown in fig. 1. The pump is placed on the top of the scaffold G; it has two barrels I I, which are worked by a lever K, by one or two men; they act as forcing pumps, and the air which is thrown down escapes from the lower edge of the bell, and rises up through the water in bubbles. By this means the air in the bell is at all times quite fresh and pure.

The stones which are to be used in building the wall are prepared on shore, and fitted to each other. When all is prepared, these stones are lowered down the bank by a capstan to the position *w*. The rope of the machine is then attached, and by the aid of both ropes the stone is lowered down upon the wall. The divers then descend in the bell, and the two carriages are brought close together, by which means the bell will hang partly over the stone W, fig. 2, so that the men can guide it into its place on the wall X, and make signals to those above to direct them which way to move the stone, and where to lower it. The bell was also employed, in the first instance, to clear the foundation for the walls. It was then lowered quite down on the bottom, and the men worked the rock to a level surface. In many parts it was requisite to blast it with gunpowder. The divers bored the hole in the rock, and placed the powder in a tin cartridge, which was well secured in the hole, by running in small fragments of stone. A small tin pipe was affixed to the canister, long enough to reach up above the surface of the water. When all was prepared, the bell was drawn up out of the way, and a nail or other small piece of iron heated red hot, was dropped into the tin pipe, thereby to descend to the powder.

Figures 3. and 4. represent a vessel which was fitted up under the direction of Mr Rennie, to carry a diving bell of cast-iron. This was used in Plymouth Sound, and was swept over the bottom to discover and take up old anchors, &c. The bell A is suspended over the bow of the vessel, by a strong tackle *q*, from the extremity of a pair of shears; that is, two masts DB DB, fig. 4. The fall or rope of the tackle *q* is drawn up by a windlass at C. There is also another strong tackle GH, extended between the head of the mast I and the top of the shears D. This is drawn by the windlass F. The use of this is to raise the shears upright, and bring the bell on board. A platform S is fixed on the deck to lower it upon, when out of use.

(B.)



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DOCK,

Dock.

An inclosed space for the reception of ships, either for their security, or for the convenience of building or giving them repairs. This word has been derived, absurdly enough, from the Greek, δεχομαι, to receive. That we had it, along with almost the whole of our sea-terms, from the northern continental nations, is sufficiently obvious. Thus, in Flem. it is *dok;* Teut. *dock;* Swedish, *docka;* Suio-Goth. *docka;* perhaps originally from *dekken*, to cover, protect, secure, inclose. The *dock* for inclosing the prisoner in a court of justice is evidently from the same origin.

Docks for the reception of ships are of two kinds, *wet* and *dry*.

A *wet dock* may either have gates, to retain the water in it, so that ships shall constantly remain afloat, or be left open for the tide to flow into and ebb out of it at pleasure; either leaving it dry at low water, or with a certain depth of water remaining in it, according to its construction and situation with regard to the low water mark, and to the ebbing of the sea at spring or neap tides. A wet dock, without gates, is generally distinguished by the name of a *basin*, which, however, is sometimes indiscriminately applied to a wet dock, whether with or without gates.

A *dry dock* either becomes dry by the ebbing of the tide, when the gates are left open, or by shutting the gates at low water, and pumping out whatever water may remain in it at that time, by the power of men, horses, wind, or, which is now most commonly performed in the King's dock-yards, by the steam-engine.

A *wet dock*, therefore, may be defined to be "a basin of water, in which ships may be kept afloat at all times of the tide;" a *dry dock* a "receptacle in which every part of a ship can be examined, and its defects repaired." Ships may also be conveniently built in dry docks, and floated out by opening the gates; though, in all dock-yards, there are places set apart for this purpose, under the name of *slips*. A wet dock is called by the French *un basin;* a dry dock, *une forme;* and a slip, *un calle*.

The digging out the earth, and building the surrounding walls of masonry, to prevent the sides falling in, the preparation of the mortar and puzzolana, in the construction of a wet dock, are attended with great labour and expence. The two wet docks or basins of Cherbourg (see Breakwater), which are probably the finest specimens that exist in the world, are estimated to have cost three millions Sterling. The labour of excavation may sometimes be spared, and a series of wet docks or basins conveniently made by turning the course of a tide-river through an isthmus, and placing a pair of gates at each end of the old channel. In this way were the new docks of Bristol constructed, out of the bed of the Avon.

Wet Docks.

Wet docks are an improvement in navigation and commerce of the utmost importance, but of very modern date in this country; indeed, they owe their introduction entirely to a spirit of individual enterprise in commercial speculation. Liverpool might still have remained a poor fishing village, but for its convenient docks, which not only produce to the town and corporation a large revenue, but ensure to the merchant every possible facility in refitting, loading, and discharging his ships, whatever their burden or their cargo may be, without being exposed to the risk of losing both ship and cargo in a rapid tide river; and, at all events, to an unavoidable delay, occasioned by distance, the weather, or the state of the tides.

Hull is also greatly indebted for the extension of its commerce to its docks. Its old wet dock contains an area of ten acres nearly, and has accommodated at one time 130 sail of such vessels as frequent that port.

London, though unquestionably the first city in the world for its opulence, its commerce, and public spirit, and possessing within itself the powerful internal means of supporting docks, and all other conveniences that trade and shipping may require on the most extensive plans,—London has been the last to try the experiment of docks, except in the case of two spirited individuals, Mr Perry at Blackwall, and Mr Wells at Greenland Dock, both private ship-builders. Notwithstanding the total inadequacy of legal quays, which subjected the merchants to incalculable losses and delays, and in many cases proved absolutely ruinous; notwithstanding the effect of the heavy, expensive, and fatal embarrassments experienced regularly on the arrival of the West India fleets, and the annual losses, by plunder in the river, on West India produce, which, alone, were calculated to amount to L.150,000 to the proprietor, and L.50,000 to the revenue, and more than the double of those sums, including other branches of commerce,—it was not till the year 1799 that prejudices and private interests were so far removed, as to enable the merchants concerned in the West India trade to obtain an act of Parliament to carry into execution a plan of docks, quays, and warehouses, for the convenience of that trade, on the Isle of Dogs.

The docks of Liverpool were the first of the kind that were constructed in this kingdom, by virtue of an act of Parliament passed in 1708, and from that period the town of Liverpool has rapidly raised itself from a poor fishing village, and a port for coasting vessels, to be the second commercial town and port in the empire; and the plan of improvements now carrying into execution for the enlargement and better arrangement of the docks, will, when completed, render it, for convenience and appearance, in this respect, the very first, not London even excepted.

It appears from a statement, apparently authentic,

Dock.

that, in the ten years ending with 1808, the number of ships that entered these docks was 48,497, tonnage 4,954,204; and the dock duties received L. 329,566; and that, in the following ten years, ending in 1818, the number of ships was 60,200, the tonnage 6,375,560, and the amount of duties L. 666,438. It may also be observed, that this extraordinary increase has taken place since the abolition of the slave-trade, which, it was asserted, would be the ruin of Liverpool.

The docks of Hull have also been advantageous, though in a less degree, to the wealth and prosperity of this trading town. The docks at Leith, when completed, will afford security and convenience to the increased commerce of the capital of Scotland.

The *West India docks* on the river Thames commenced in February 1800, and were opened in August 1802. They consist of an outward and a homeward-bound dock, and communicate by means of locks with a basin of five or six acres on the end next to Blackwall, and with another of more than two acres at the end next to Limehouse, both of which basins communicate with the Thames. The outward bound dock is about 870 yards in length by 135 in width, containing consequently an area of more than 24 acres; the homeward bound dock is of the same length, and 166 yards in width; its area being little short of 30 acres; and the two together will contain, with ease, at least 500 vessels from 250 to 500 tons. The whole are surrounded with a high wall; and, as a security against fire, the moment that a ship enters the dock the crews are discharged, and no person whatever is allowed to remain on board, or within the premises, the gates of which are closed at a certain hour. They are surrounded by immense warehouses which are estimated to contain nearly 10,000 hogsheads of sugar, and an immense quantity of rum. The sum authorized by Parliament to be raised for completing these docks and warehouses was L. 1,200,000, and the total expence was probably not far short of one million and a half; yet on this capital, the subscribers have been receiving from a very short period after their opening 10 *per cent.* which, by the terms of the act, is not to be exceeded; and the term granted is limited to 21 years.

The next set of docks that were undertaken for the advantage of the trade of the capital was the *London Docks.* These docks are situated in Wapping, and are appropriated for the reception of all ships arriving in the port of London with wine, spirits, tobacco, and rice on board; but not exclusively, ships having on board other cargoes being admitted, on the payment of certain fees. The act of Parliament for incorporating the dock company was passed in 1800, authorizing them to raise a capital of L. 1,200,000, but such was the number of houses to be purchased (we believe not less than twelve hundred) occupying the site of the dock, that this capital, by subsequent acts, was extended to L. 2,200,000; the dividends on which are limited, as in the West India docks, to 10 *per cent.* The great dock is 420 yards in length, and 230 yards in width, covering an area of 20 acres. A basin of three acres nearly connects it with the river. The warehouses are very magnificent; the tobacco warehouse is the grandest and most spacious building of its kind in the world; being capable of containing five and twenty thousand hogsheads of tobacco, and the vaults underneath as many pipes of wine. This single building, under one roof, is said to occupy upwards of four acres of ground. These docks were opened in February 1805.

The *East India Docks*, for the exclusive reception and accommodation of the East India ships, were the last in succession. The act for the incorporation of the Company was passed in July 1803, authorizing them to raise a capital of L. 200,000, which was afterwards increased to L. 600,000, the dividend, as in the case of the two others, to be limited to 10 *per cent.* These docks are situated at Blackwall. That for the reception of homeward bound ships is 470 yards in length, by 187 in width, containing a surface of rather more than 18 acres; the outward bound dock is 260 by 173 yards, and is consequently something more than 9 acres. An entrance basin of three acres nearly, and a spacious lock, connect them with the Thames.

Dry Docks.

A dry dock, requiring to be perfectly water tight, demands the greatest care in its construction: it is sometimes lined all round with wood, but more generally with masonry, mostly of hewn granite. The expence is very considerable, as the foundation, by means of piles or otherwise, must be well secured, all leakage prevented, and the culvers or drains properly constructed, to let in and carry off the water without its undermining the quays or piers. The cost of a complete dry dock will vary probably from L. 20,000 to L. 100,000, according to the size of the ships it is intended to admit, and the nature of the ground on which it is to be constructed. A dry dock may be *single*, or made to contain only one ship; or *double*, to contain two ships; but the former is the most common, because most convenient.

As it is of the utmost importance to preserve the water *in* a wet dock, and to keep it *out* of a dry dock, it may be proper to describe the different kinds of *gates* that are in use for this purpose.

Dock Gates.

The most common, and, on the whole, perhaps, the best and most convenient, are SWINGING GATES, which open in the middle, and lie flat, one part against each wharf or side-wall of the passage, leading into the dock or basin. The elevation of this kind of gate is represented in Plate LXXI. fig. 3. This kind of dock gate requires to be made of great strength, with sound timber and good iron, and the gudgeons on which the hinges turn, to be well secured into the stone abutments. Care also must be taken, to make the bottom of the passage and the bottom of the gates perfectly plane and parallel, to prevent leakage, and give facility to their opening and shutting, which is usually assisted by rollers fixed in a groove, and performed by means of a small capstern on each pier. Attached to the top of the gates is usually a foot bridge with railing, which, separating in the middle, opens and shuts with the gates.

Dock.

The most simple, but by no means the most effective, contrivance for keeping out the water, is the wicket-gate, of which the plan and elevation are represented in Plate LXXI. fig. 5 and 6. It consists of three parts, which, when opened, are removed separately. This gate is rarely made use of unless where the abutments are not sufficiently strong, or their foundation sufficiently secure, to bear the weight of a pair of swinging gates.

A third kind of gate consists of a floating dam or caissoon, first introduced into this country by General Bentham, and first applied to the great new basin in Portsmouth dock-yard. They are built somewhat in the shape of a Greenland fishing-boat, sharp at the two ends, narrow, and deep in proportion to the depth of water at the entrance of the dock. The keel fits into a groove at the bottom of the passage, and the two slanting ends rise and fall in corresponding grooves cut into the two abutments. Of this kind of gate, fig. 1 and 2 Plate LXXI. represent the plan and elevation. By letting in the water the caissoon sinks in the grooves, and acts as a closed gate; and by pumping out the water, or letting it out to a certain depth, the dam floats, as the tide rises, and the narrow part, rising to the top, is readily disengaged from the grooves, and easily floated away as a boat. The advantages of these floating dams, as stated by General Bentham, are, that they are cheaper of construction than the gates heretofore in use for closing docks or basins; that they occupy less space, are more easily repaired, and one and the same dam is capable of being used, as need may require, in different places at different times. These caissoons have also the advantage of serving as bridges of communication for loaded carriages, across the entrances they close, and require much less labour than gates, in opening or shutting up passages into docks or basins; since their occasional buoyancy may be obtained without pumping water, or unloading ballast.

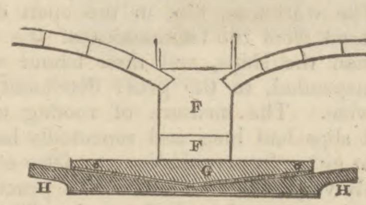
Fig. 7. represents a plan, and fig. 4. a sectional elevation of a DRY or GRAVING DOCK, into which ships are taken to have their defects examined and repaired, coppered, &c. and in which, if necessary, as already observed, ships may be built.

ocking a ip.

When a ship is brought into a dry or graving dock, she gradually subsides as the water flows out, till her keel rests upon the line of square blocks, which are placed to receive it along the middle for the whole length, and on these blocks she is kept steady and upright by a number of shores or poles on each side, one of their ends being placed on the *altars*, or steps of the dock, the other under the ship's bends and bottom. As a ship under repair generally requires something to be done to the main or false keel, or at any rate these parts require to be inspected; sometimes to shift the main keel or to add to the whole length of the false keel, it was always found necessary, in such cases, to remove the blocks in order to get at the bottom of the ship; but this operation could not be performed without the more serious one of first *lifting* bodily the ship clear of all the blocks, and suspending her, as it were, in the air. This process was performed by driving wedges simultaneously under the ends of all the shores that supported the ship; an operation that required from four to five hundred men to enable them to suspend a ship of the first rate. When the San Josef, a large three-decker, required her bottom to be examined, in 1800, the assistance of almost every artificer in the dock-yard was found necessary to perform this process of lifting her; nor was this the only inconvenience, the ship, thus suspended, suffered very material injury by the pressure of her own enormous weight against the ends of the shores that supported her, such as forcing in her sides, straining the knees and all her fastenings, breaking the treenails, &c.

To remedy these glaring inconveniences and very serious injuries that ships thus placed were apt to sustain, and to effect a saving of time and expence in the operation, Mr Seppings, then Master Shipwright, and now Surveyor of the Navy, contrived, sixteen or eighteen years ago, an improvement, as ingenious as it is simple, by which twenty men will suspend the largest ship in the navy, or rather, which amounts to the same thing, will disengage any one block that may be required in the space of two or three minutes, without the necessity of suspending her at all; and, as a first rate in dock sits upon about fifty blocks, these twenty men will clear her of the whole of these blocks in about two hours; and, as the saving of a day in completing the repairs of a ship, is frequently the saving of a whole spring tide, the docking and undocking of a ship may make, and frequently has made, by this new method, the difference of a fortnight in the time of equipping her for sea.

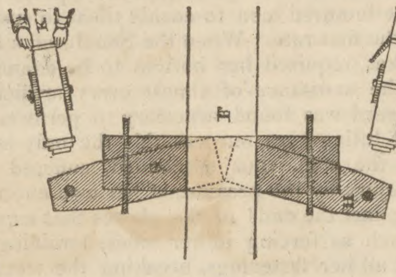
The block of Mr Seppings, instead of being one solid piece, consists of three wedges, or, more properly speaking, of one obtuse wedge, and two inclined planes, which, when put together and placed under the ship's keel, appear as under, when viewed in the direction or line of the keel:



where G is the wedge on which the keel rests, having its obtuse angle equal to 170^0, and HH are the two inclined planes, each having an acute angle of 5^0. The wedge is of hard wood, having its two sides lined with iron; the two inclined planes are of cast-iron. When one of these blocks is to be disengaged from under a ship's bottom, nothing more is required than a few smart blows alternately on the two sides of the two inclined planes, when they fly out, and the middle part or wedge drops, and the facility of thus disengaging any of the blocks, is in proportion to the quantity of pressure upon that block. The strokes are usually given by a kind of

Dock.

catapulta or battering-ram, being a thick spar or pole moving on a pair of wheels, as KK. This sim-



ple contrivance to get at any part of a ship's bottom by removing, in succession, all the blocks without the necessity of lifting the ship, which the removal of any one block required to be done by the old method, is now universally adopted in all the dock-yards; and the Lords of the Admiralty marked their sense of the great utility of the improvement, by bestowing on Mr Seppings a reward of L. 1000 for the invention.

Roofing the Docks.

Another very material improvement, recently introduced into his Majesty's dock-yards, is that of covering the dry docks and building slips with roofs. The rapid decay of our ships of war by that species of disease known by the name of the *dry-rot*, attracted very general attention; its effects were well known, but a variety of opinions were entertained as to its causes and its cure. It was quite obvious, however, that exclusion of air and moisture were the two great operating causes in giving activity to the progress of the disease (see DRY-ROT); and that a ship in dock, stripped of her planking, and open to the weather in every part, alternately exposed to frost, rain, wind, and sunshine, must at least have her timbers differently affected, some swelled and water-soaked, others shrunk with heat, and others rifted with the wind and frost; and, if closed up with planking in this state, might be expected, at no great distance of time, to exhibit symptoms of a decay. The workmen, too, in the open docks or slips, suffered from the vicissitudes of the weather no less than the ships, and their labour was frequently suspended, to the great detriment of the naval service. The measure of roofing over the docks and slips had long and repeatedly been suggested, but either from prejudice or a false economy, it was only very recently carried into practice, but is now almost universal in all the yards. These roofs are generally constructed so as to be capable of having the sides and ends occasionally closed according to the quarter from which the wind may blow; and, by this contrivance, the timber is prevented from rifting, as it is liable to do, by the action of a thorough draught of wind, and the health of the artificer is prevented from injury. The light is admitted through numerous windows placed in the roof. These roofs are, in general, supported on a row of wooden pillars, and covered with slate, some with plates of iron, and others with shingle. Plate LXXII exhibits the transverse section of a roof thrown over the head of the dock at Plymouth, in which the Foudroyant is repairing; its span being 95 feet 4 inches, and the extreme width 125 feet 4 inches, supported, on the principle of trussing, without a single beam. Another of the same kind is building over the Prince Regent at Chatham, whose span is 100 feet, and the extreme width 150 feet. These immense roofs are constructed after a plan of Mr Seppings. The cost of one of the dimensions above mentioned is from L. 6000 to L. 7000, which, great as it may appear, will be amply repaid by the superior quality and durability of the first ship built under it; but the same roof, with little or no repair, will, in all probability, serve as a covering for eight or ten different ships in succession. General Bentham who, in his statement of "*Services rendered in the Civil Department of the Navy*," seems to claim to himself all the *iuventions* and improvements that have been introduced into the dock-yards for the last twenty years, carries his *invention* beyond a mere covering, and proposes to house over the docks and slips so completely, as to afford "means of heating, warming, ventilating, and artificially lighting the interior at pleasure; the introduction of boilers or steam-kilns for bending the planks, within the inclosure; the introduction of machinery for assisting in various operations, particularly the more laborious ones; the providing room for carrying on all the shipwright's work within the building; besides a variety of lesser works, such as it is found very inconvenient during the building or repairing of a ship, to have executed, for example, in a smith's or carpenter's shop at a distance." Such buildings would not only be enormously expensive, but, in the present crowded state of the dock-yards, utterly impracticable. With regard to the *invention* of covered docks and slips, they have been used in Venice from time immemorial; and it appeared, from the evidence given by Mr Strange, the Consul at that port in the year 1792, before the Commissioners of Land Revenue, that two-and-twenty large ships had been under covered slips, some of them for sixty years nearly. At Carlscrona, also, there are several covered docks; and both Mr Nicholls and Mr Snodgrass strongly recommended the building of ships under cover nearly thirty years ago.

Hauling up Ships on Slips.

Among other experiments that have recently been making in the dock-yards for facilitating and expediting the repairs of ships, one may be mentioned, of which many persons are sanguine enough to think that the successful result is likely to be attended with most important benefits to the naval service. It is that of hauling up ships of war, of any dimensions, on building slips, instead of taking them into docks. It is no uncommon practice, at various ports of this kingdom, where there are neither artificial basins nor natural harbours, to haul vessels of the burden of fifty to two hundred tons, or probably larger, upon the beach by means of capstans, to give them repairs; in like manner, most of the large fishing smacks are hauled up for security in tempestuous weather; but the practicability of hauling up ships of war, especially of the larger classes, was a matter of some doubt. Several frigates had, at various times, been hauled upon slips, when the docks were all occupied, and the ease with which the ope-

Fig. 1.

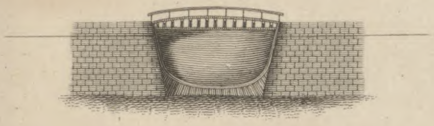
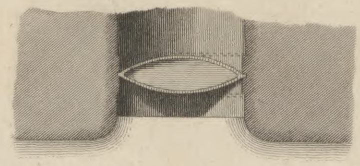
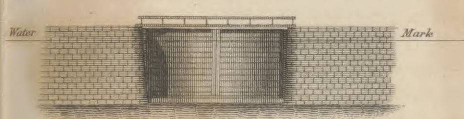


Fig. 2.



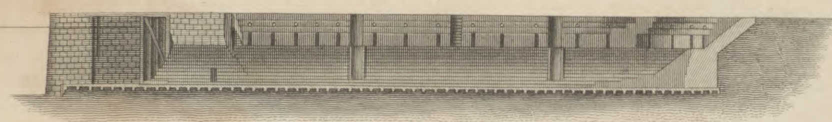
PLAN AND ELEVATION of the entrance to the Dock with a *FLOATING DAM.*

Fig. 3.



ELEVATION
of the entrance to the Dock with Swinging Gates.

Fig. 4.



SECTIONAL ELEVATION OF THE DOCK

Fig. 5.

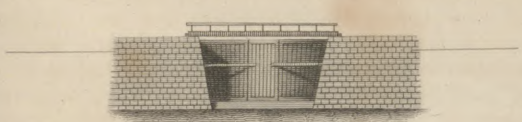
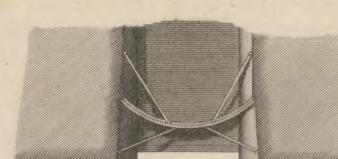
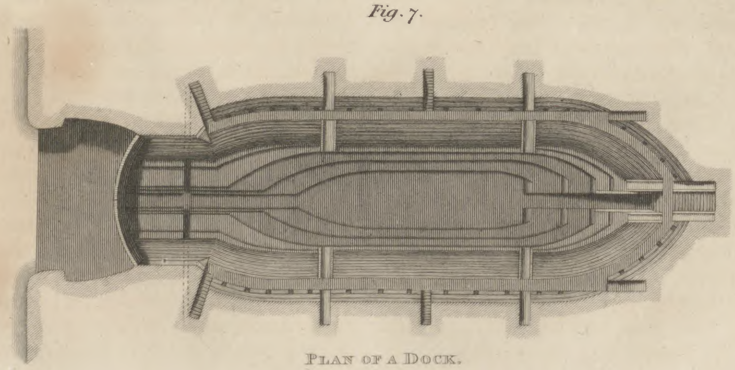


Fig. 6.



PLAN AND ELEVATOIN of the entrance to the Dock with *WICKET GATES.*

Fig. 7.



PLAN OF A DOCK.

Engraved by W.&D. Lizars Edin.r

Published by A. Constable & C.o 1818.

Drawn by W. Edye, for the Suplement to the Encyclopædia Britanica.

Engraved by W. & D. Lizars Edinburgh

TRANSVERSE SECTION OF A ROOF OVER THE HEAD OF THE DOUBLE DOCK, AT PLYMOUTH, ERECTED IN 1817. DESIGNED BY R. SEPPINGS, SURVEYOR OF THE NAVY.

ration was performed, induced the officers of the dock-yard to propose the hauling up of a line of battle ship. The Kent, of 74 guns, was selected for this purpose. It was necessary, in the first place, to take her into a dock, to have proper bilgeways prepared, and to be stripped so as to be made as light as possible, her weight being, according to a calculation made from the water she displaced when afloat, about fourteen hundred tons. To heave up this weight fourteen capstans were employed, and the number of men to work these were as under:

9 men to each bar and swifter,	-	1512
8 —— to hold on at each,	- -	112
3 —— to each capstan, to attend the fall,		42
Men on board the ship, and employed in other operations,	- - -	450
Total of men employed,	-	2116

The time occupied in hauling her up, after all the purchases were brought to bear, was forty minutes. The expence of preparing her, and the loss and wear and tear of the materials, was estimated at somewhere about L. 2000.

The advantages which slips are supposed to possess over dry docks are many and important. They can be constructed at one-twentieth part of the expence; they occupy less space; they can be constructed on a steep or a shelving shore, and ships can be hauled upon them either in spring or neap tides; whereas a dry dock can only be made in particular situations, and, when made, ships can only be docked and undocked in certain states of the tides; from which circumstance, a considerable delay and inconvenience are frequently experienced. It should be recollected, however, that a large ship must necessarily go into a dock preparatory to her being hauled up on a slip.

It has been considered as not at all impossible, as was suggested some time ago by Mr Perring, the ingenious clerk of the check in Plymouth dock-yard, that the whole ordinary may hereafter be laid up on slips, which, if housed over, would unquestionably be the best means of increasing their durability, and preserving them from partial decay. Nor is it certain, that in the end it would not be the most economical mode of preserving them. The expence, as appears from the *Estimates of the Ordinary of the Navy*, for the year 1817, is L. 187,000 for harbour victuals, harbour moorings and riggings, &c. besides L. 135,000 for wages; the chief part of both which sums is on account of ships of war laid up in ordinary, none of which would be required by placing them on slips. It would, indeed, form a singular revolution in naval management, if ships hereafter should be laid up in ordinary on dry land, whilst the timber of which they are built is now considered to be the best preserved under salt water: a process which from some experiments recently made, promises fair to be the most effectual prevention of, and a probable cure for the dry rot. (See DRY-ROT.) This method of preserving timber has long been practised at Brest, Carthagena, and several other places on the Continent; and the only objection to it in some of our ports appears to be the attack of the worm, known to naturalists by the name of *Teredo navalis*, whose bite is almost as destructive as the dry-rot.

On the other hand, there are very many and serious objections, even were the measure practicable, of hauling up ships of the line in particular, to be laid in ordinary on slips. In the first place, the length of sea-beach that would be required is greater than probably all the dock-yards in the kingdom could furnish. Secondly, the three warrant-officers who are now employed in each ship, and who are the best men in the service, being no longer necessary, would be turned adrift, and, in all probability, utterly lost to the navy. Thirdly, no large ship could be hauled on the slips without being previously taken into a dock to have her bilgeways fitted, and her bottom prepared for placing her on the slip. The time taken for this purpose must necessarily interfere with the other works of the yard, and after taking her out, the preparations for heaving her up, the capstans, blocks, purchase-falls, chains, and a variety of other articles, amount to a very large expence, not less, with the expence of the roof to cover the ship, than L. 10,000 for each slip so hauled up.

Dock-Yards.

Previous to the reign of Henry VIII. the kings of England had neither naval arsenals, nor dock-yards, nor any regular establishment of civil or naval officers to provide ships of war, or to fight them. They had admirals, however, possessing a high jurisdiction and very great power. (See the article ADMIRAL *in this Supplement.*) And it would appear, from a very curious poem in *Hackluit's Collection*, called "*The Policie of Keeping the Sea*," that Henry V. had both ships, officers, and men exclusively appropriated to his service, and independent of those which the Cinque Ports were bound, and the other ports were occasionally called upon, to furnish, on any emergency. By this poem it also appears that Litle Hampton, unfit as it now is, was the port at which Henry built

> ——————"his great *Dromions*
> Which passed other great shippes of the commons,"

but what these *dromions* were no one now can tell; nor is it easy to conceive how the building and repairing of the Great Harry, which in the reign of Henry VII. was launched at Portsmouth, and cost L. 15,000, was managed, considering the very rapid strides made at once from the small Cinque Port vessels, manned with twenty-one men and a boy, to this enormous floating castle; at that time it is well known they had no docks nor substitutes for them.

The foundation of a regular navy, by the establishment of dock-yards, and the formation of a board, consisting of certain commissioners for the management of its affairs, was first laid by Henry VIII., and the first dock-yard created under his reign was that of Woolwich. Those of Portsmouth, Deptford, Chatham, and Sheerness, followed in succession; and the last, excepting the new and unfi-

nished yard of Pembroke, was Plymouth, which was founded by William III.

From the first establishment of the King's dock-yards, to the present time, most of them have gradually been enlarged and improved by a succession of expedients and make-shifts, which answered the purposes of the moment; but the best of them possess not those conveniences and advantages which might be obtained from a dock-yard systematically laid out on an uniform and consistent plan, with its wharfs, basins, docks, slips, magazines, and work-shops, arranged according to certain fixed principles, calculated to produce convenience, economy, and dispatch.

Imperfections of the King's Dock-yards. Neither at the time when our dock-yards were first established, nor at any subsequent periods of their enlargement as the necessities of the service demanded, could it have been foreseen what incalculable advantages would one day be derived from the substitution of machinery for human labour; and without a reference to this vast improvement in all mechanical operations, it could not be expected that any provision would be made for its future introduction; on the contrary, the docks and slips. the work-shops and storehouses, were successively built at random, and placed wherever a vacant space would most conveniently admit them, and in such a manner, as in most cases to render the subsequent introduction of machinery and iron railways, and those various contrivances found in the large manufacturing establishments of private individuals, quite impossible, even in the most commodious and roomy of his Majesty's dock-yards.

Proposals for a Dock-yard on the Isle of Grain. The want of a systematic arrangement in our dock-yards, independent of machinery, and the enormous expenditure of money laid out on expedients, were questions of frequent discussion among naval men connected with the various administrations of the navy, and it was thought by many that it would be more desirable to construct an entire new dock-yard in some eligible situation, on an extensive scale, than to continue the *improvements* in the old ones. For this purpose, so early as the year 1765, the attention of the naval administration appears to have been turned to the Isle of Grain in the river Medway, along the shore of which is a fine expansive sheet of deep water. A dock-yard thus placed, on a systematic plan, would supersede that of Chatham on one side and Sheerness on the other; but it was discovered on boring that the substratum was so loose and sandy, as not to admit of a solid foundation. General Bentham, however, revived the project in the year 1800, which he seems to claim as his own, and painted the situation in such glowing colours, and as affording so many advantages for a grand naval arsenal, that the Lords of the Admiralty were induced to order a fresh set of borings to be taken. They were carried to the depth of sixty feet, and were every where found to consist of sand and mud, and totally unfit for the construction of basins, docks, and such solid buildings as are required for naval purposes.

On the Peninsula of North-fleet. The imperfection of the naval yards to the eastward, the extension of the boundaries of France towards that quarter, the occupation of the great naval port of Antwerp, and the uninterrupted command of the Scheldt and the ports of Holland by that power, rendered an enlargement of the means of naval equipment in the eastern dock-yards of England, or a new naval arsenal, indispensable. For the latter purpose, the banks of the Thames were considered, in every point of view, as preferable to those of the Medway, the entrance into the latter being narrow, and having a bar across it, on which, at low water of spring tides, there is only 14 or 15 feet of water; whereas the navigation of the Thames is at all times uninterrupted, excepting by the badness of the weather. It communicates directly with the great market of London, in which every description of stores, foreign and domestic, is accumulated; and the trade of the Thames is the great source from which the fleet is supplied with seamen. The marshy peninsula of North-fleet was considered by naval men, who had turned their attention to the subject, to possess every possible requisite for the establishment of a royal dock-yard, on an extensive scale. It was sufficiently removed from the mouth of the river to be completely sheltered, yet near enough for ships to proceed to sea with one wind. In the river between North-fleet and the sea, there is plenty of water for the largest three-deckers to proceed with all their guns, ammunition, stores and provisions, on board, and almost with any wind, if moderate. A copious stream of good fresh water runs across the peninsula. The soil afforded plenty of earth, suitable for bricks; the foundation was excellent for docks, slips, wharfs, and buildings of all kinds. It was sufficiently near the metropolis for speedy communication with the naval departments, and to receive stores in barges and the river craft. It was capable of being defended both on the land and river side; and when the whole was raised to the height of twelve feet with a dry gravelly soil, from the excavations of the docks and basins, there could be no doubt of the healthiness of the situation. By the direction, therefore, of the Lords of the Admiralty, a complete survey was made by Messrs Rennie and Whidbey, who furnished a plan and estimate of a naval arsenal, on a magnificent scale, within which all kinds of machinery were proposed to be employed, for the making of anchors, sawing of timber, rope-making, block-making, &c. Iron railways to be laid from the timber wharfs to the timber fields, from thence to the mills and pits, and from them to the docks, slips, and workshops. The estimate, it appears, was about six millions sterling, which Mr Rose, in his letter to the late Lord Melville, calculates, with the fortifications and unforeseen expences, to amount actually to ten millions; an expence which the minister did not venture to propose, though there can be little doubt that, when the case was fairly stated to the public, and the necessity of increasing our naval establishments to the eastward had been made apparent, no violent opposition would have been made to a measure, which tended to keep up our naval superiority, and which was the less objectionable, as none of the money would have been taken out of the country, but circulated within it, to the encouragement of the arts, trades, and manufactures of the kingdom.

The Board of Revision made a detailed report on the merits of the plan, which, however, as the exe-

cution of it was delayed, was not printed; but the real reason was supposed to be, that of the very gloomy view taken by the Commissioners, of the disadvantages and imperfections of the present dock-yards, which Mr Rose seems to think, and, indeed, it is generally thought, is by no means warranted, and that those disadvantages, in that report, are greatly exaggerated; perhaps to enhance the value of the North-fleet plan, of which they seem to have been much enamoured. Imperfect as the old dock-yards are, chiefly from their having risen, as before observed, to their present state, by a succession of expedients and make-shifts, they are, nevertheless, far superior to any similar establishments on the Continent of Europe; if we except the unfinished arsenal of Cherbourg, whose magnificent basins (see BREAKWATER) are certainly unequalled, and the space surrounding them capable of being turned to every possible advantage. M. Ch. Dupin, a French officer, who lately examined all our dock-yards with a skilful eye, pronounces them as by far superior to any on the continent. We have heard much of the magnificent basins and the covered docks of Carlscrona, but the one has been greatly overrated, and the others are merely covered over with shed-like roofs; nor is there the least likelihood that the plan will ever be finished. We have been told likewise of the superior advantages of the naval arsenal of Copenhagen, where every ship has its appropriate storehouse. This plan has been adopted at Brest, and is reprobated there by every naval officer, and the officers of the yard, as most inconvenient, and a great waste of room, by having the most bulky and the most trifling articles stowed together in the same room. A better arrangement is, that of having certain magazines appropriated to certain kinds of stores, and arranged according to the class or rate of ship for which they are intended; and if appropriated or returned stores, the name of the ship to which they belong painted in front of the birth in which they are deposited. This is the system generally followed in our dock-yards.

The great point in which our naval arsenals are most defective, is the want of wet-docks or basins; which, however, are, to a certain extent, compensated at the two principal dock-yards of Portsmouth and Plymouth, by two magnificent harbours, in which the whole navy of England, when dismantled, may be moored and laid up in ordinary, in perfect security. The want of basins, however, in our dock-yards, are most severely felt in time of war, when the expeditious fitting out of the fleet becomes so very desirable. One at Portsmouth, on a small scale, has been found of incalculable advantage to that yard; and a larger one, now constructing at Sheerness, will probably make that yard of sufficient capacity to supersede the necessity of a new establishment at North-fleet, or in any other situation to the eastward.

Idea of a perfect Dock-Yard.

The perfection of a dock-yard, then, independent of the advantages of machinery, which are but contingent, may be considered to depend upon one or more extensive basins, surrounded by spacious wharfs or quays. By means of these a prodigious saving of time, labour, and expence, may be saved, in every stage of the progress of fitting out a ship for sea, from the moment she is launched from the slip, or taken out of a dock, as well as in dismantling a ship on returning to port to be paid off and repaired, or laid up in ordinary. For this purpose the docks and slips should occupy one of the sides of the basin, with working sheds for carpenters and joiners, smiths' shops, saw-pits, and seasoning-sheds between them. The ship, when completed on the slip and launched into the basin, may then be taken immediately into the adjoining dock to be coppered. From this she proceeds to the second side of the basin, in the corner of which is the ballast wharf; the remainder of the side will probably be occupied by the victualling department, with appropriate stores in the rear for various kinds of provisions, and behind these the bakery, brewery, and slaughter-houses; on the wharf the iron tanks for holding water, now universally used for the ground tier, in lieu of wooden casks. These are taken on board next after the ballast, and, together with the superincumbent casks, would be filled in the ship's hold, by means of flexible pipes to convey the water into them. The provisions would, at the same time, be taken on board at the same wharf, in front of the victualling stores. The third side might be appropriated to the ordnance department, with the gun wharf extending along the whole side, and the gun-carriage storehouses, magazines, &c. in the rear. The fourth side would be occupied as the anchor wharf, with the cable storehouses, the sail lofts and stores, rigging loft, and magazines for various stores in the rear. Behind these again, on the first side, containing the dry-docks and building-slips, the ground would be appropriated to the reception, birthing, and converting of timber, from whence iron railways would lead to the saw-mills, saw-pits, and workshops, all of which would be placed on that side. On the second side a pond or basin for the victualling lighters and craft, with wharfs communicating with the manufactories and storehouses. The same on the ordnance or third side; and on the fourth side might be placed the ropery, hemp storehouses, tar-houses, with a basin for hemp-vessels, lighters, &c. Communicating with the great basin on the building side, and also with the river or harbour, on the shore of which the dock-yard is to be formed, should be a mast-pond, with a lock for the storing of spars; in front, the mast-houses, top-houses, capstan-houses, and a slip to launch the masts into the pond. Here, also, might be placed the boat-houses, and boat-pond.

Advantages of a Systematic Dock-Yard.

A peninsular situation, like that of North-fleet, having, at least, three-fourths of its shore surrounded with deep water, is peculiarly favourable for some such arrangement as is here mentioned; as any number of locks and canals might be made to communicate with the river, so that ships coming into the basin might not interfere with those going out, nor the lighters and other craft bringing their several species of stores, with either, or with one another. By such an arrangement a ship would be equipped for sea at half the present expence, and within half the usual time. A ship fitting out for an anchorage distant from the dock-yard, as at the Nore and Spithead, is liable to every inconvenience and delay;

Dock-Yards. as all her guns, stores, provisions, and water, must be carried to her in dock-yard lighters and other craft, into which and out of which they must be hoisted and rehoisted; liable to delay from bad weather and contrary winds; to be stove alongside the ship, to the total loss or damaging of their cargoes; added to which, is the loss of time in going backwards and forwards, especially to the artificers; the desertion of the men; the accidents from the upsetting of boats; and many other evils of a magnitude not easily to be calculated, and exceeded only by the disappointment and vexation that unavoidably occur when ships are preparing for some particular and pressing service; all of which, when ships are fitted out in a basin for sea, are avoided. Here no delay, no embezzlement, no desertion, can take place. A ship in returning from sea may be docked and undocked into the basin with all her stores on board; and if to be paid off, instead of keeping the crew on board for weeks, till all the stores have been delivered into the dock-yard, the ship, by the proposed plan of basins, would remain securely in the basin, to be stripped at leisure by the riggers and labourers of the yard, and the crew become immediately available for other ships. Of the many superior advantages of wet docks for laying up ships to discharge, over the practice of exposing them in rivers or harbours, the shipping interest of the port of London, Liverpool, Bristol, and Hull, can best testify, more especially that of London, which has taken the precaution to surround the docks with high inclosing walls, by means of which all access is debarred, and all possibility of embezzlement prevented.

Royal Dock-Yards. From a brief description of the royal dock-yards as they now stand, a general idea may be formed of their several capacities, advantages, and defects. Taking them in succession, according to their vicinity to the capital, the first is

Deptford.—The front or wharf wall of this dock yard, facing the Thames, is about 1700 feet in length, and the mean breadth of the yard 650 feet; the superficial content about thirty acres. It has three slips for ships of the line, on the face next the river, and two for smaller vessels, which launch into a basin, or wet dock, 260 by 220 feet. There are also three dry-docks, one of them a double dock, communicating with the Thames, and the other, a smaller one, opening into the basin. With these restricted means, even with an adequate number of workmen, its capacity for building ships, or for large repairs, must be very limited; but in the occasional repair of fourth-rates and frigates, and in the fitting out of sloops and smaller vessels, a great deal of work was performed at Deptford in the course of the war. The proximity of Deptford dock-yard to the capital is, however, of great importance, in the convenience it affords of receiving from this great mart all the home manufactures and products which may be purchased by contract for the use of the navy. It is, in fact, the general magazine of stores and necessaries for the fleet, from whence they are shipped off, as occasion requires, to the home yards, the out-ports, and the foreign stations, in store-ships, transports, coasting sloops, lighters and launches, according to the distance to which they must be sent, to the amount, in time of war, of more than 30,000 tons a-year. Dock-Yards.

The principal stores deposited in Deptford dock-yard are small cordage, canvas and ships sails, to an immense amount; beds, hair for beds, hammocks, slops, and marine clothing; anchors under the weight of about 75 hundred, which are generally made by contract; all above that size being manufactured in the King's dock-yards.

The great magazines for the reception of these stores consist of a large quadrangular building, with a square in the middle, of three stories in height, with cellars underneath, in which are contained pitch, tar, rosin, and turpentine. The length of each side of these store-houses is nearly the same, differing from a square only by some eighteen feet; this length is about 210 feet, but they vary in width from 46 to 24 feet.

Parallel to the west front of this quadrangle is the rigging-house and sail-loft, 240 feet, and nearly 50 feet wide, in which all the rigging is fitted for ships and stowed away, the sails cut out, made, and placed in proper births for their reception, as well as for various other stores of a smaller kind.

On the eastern extremity of the yard is a long range of building, called the pavilion, in which the beds, hammocks, and slop-clothing are kept, and in which also are the house-carpenters', the joiners', and wheelwrights' shops. This building is about 580 feet long, by 26 feet wide.

The remaining buildings usually appropriated to the different services of a dock-yard, are all to be found at Deptford. A good blacksmith's-shop, a plumber, glazier, painter-shops, seasoning-sheds, store-cabins, saw-pits, mast-house and pond, boat-houses, mould-loft, timber births, besides good houses and gardens for the principal officers; with several coach-houses and stables, so that the whole space is completely filled up in every part.

The number of men employed in this yard, in time of war, may have been about fifteen hundred, of whom about one-half were shipwrights, and other artificers, and the other half labourers. There were, besides, in constant employ, eighteen or twenty teams of four each, of horses, to drag timber and heavy stores.

Adjoining to the dock-yard is the victualling-yard, the completest establishment of the kind, perhaps, in this or any other kingdom, though still capable of much improvement in the arrangement. Its frontage to the Thames is about 1060 feet, and mean depth 1000 feet, containing about 19 acres. This space is laid out in a more convenient manner than any of the dock-yards, for answering all the purposes which were intended. The general store-houses in front of the wharf wall, the cooperage, the brewery, the butchery, and the bakery, are all separate and complete in themselves. Besides all the requisite offices for keeping the accounts, there are houses and gardens for eight of the principal officers of the yard; and when the old wharf wall shall have been repaired, and carried out a little farther into the river, for which a sum of L. 27,000 appears on the estimate of 1817, the victualling-yard will be complete in all respects, according to the present arrangement.—(*Navy Estimates for* 1817.) Deptford Victualling-Yard.

Dock-Yards.

The cooperage is spacious and well laid out. The staves are all sawed by hand, and this operation employs about 100 sawyers in time of war. Mr Brown of Fulham has succeeded, it seems, in making casks by machinery, by which seventeen men in nine hours are stated to be able to complete 300 casks, whereas, by the ordinary method, the same number could only complete about eighty. The brewery is well arranged, so is the bakery; and the butchery, consisting of a yard for keeping the cattle, with pens for sheep and hogs, two spacious slaughtering-houses, cutting and salting houses, by the abundant supply of water and constant washing, are kept in the cleanest order, and free from any disagreeable smell.

In the salting season 260 carcases have been slaughtered in each of the two days in the week appropriated to killing, and the hog hanging-house is capable of containing 650 carcases.

The total number of coopers, sawyers, bakers, and labourers employed during war, in the victualling yard at Deptford, amounted probably to twelve or thirteen hundred.

Woolwich Dock-yard.—This first and most ancient of the dock-yards presents a frontage to the river of 3300 feet; the breadth very irregular, from 250 to 750 feet, and contains an area of about 36 acres. It has five slips, which open into the river, three of which are for ships of the line, one for frigates, and one for vessels of a smaller class. It has three dry docks, one a double and one single dock, all of them capable of receiving ships of the line. With all its imperfections, Woolwich yard, with a complete establishment of artificers, has been of great service both in the building and repairing ships of all classes. Some of the largest and finest ships in the navy have been launched from Woolwich yard, among which may be mentioned the Nelson and the Ocean. In fact, it is chiefly as a building yard that Woolwich ought to be considered as of much importance; and even in this respect it has, of late years, much deteriorated, owing to the increasing shallowness of the river, and the immense accumulation of mud, which is found, in a very few weeks, completely to block up all the entrances into the docks and slips, and along the whole length of the wharf wall. It is stated, in the *Eighth Report of the Select Committee on Finance* (1818), that "the wharf wall at Woolwich, owing to the action of the tide on the foundation, is in a falling state, and in danger of being swept into the river, it being secured only in a temporary manner, and requires to be immediately rebuilt in a direction that will preserve it from similar injury hereafter, and prevent, in a great degree, that accumulation of mud, which has, in the course of the last ten years, occasioned an expence of upwards of L. 125,692; and would threaten, in time, to render the yard useless."

It was, in fact, found necessary to diminish the depth of the hold of the Nelson, in consequence of the Trinity Board having stated that no vessel drawing above 19 feet of water could be navigated down to Erith Reach, and one even of that draught not without difficulty and danger.

The magazines or storehouses are not to be compared with those of Deptford. They are more confined, and, owing to the narrowness of the yard, and the progressive additions made according as necessity required, there is little or no methodical arrangement. As far, however, as regards the building and repairing of ships, its conveniences may be reckoned superior to those of Deptford. The new mast-houses and mast-slip, the new mast-ponds, and the houses for stowing yards, topmasts, &c. with the locks under them, are all excellent. The timber births are well arranged, and the addition recently made to the western extremity of the yard will allow the stacking of several thousand loads of timber, and of classing it according to the purposes to which it may be applicable; and when the new smithery, and the line of wharf-wall shall be completed, the dock-yard of Woolwich will become an important and valuable naval arsenal.

Ropery.

A considerable quantity of cables and cordage are manufactured at Woolwich; but the ropery is most inconveniently situated at a distance from the dock-yard, and great part of the town intervenes between them. Its length is 180 fathoms, but so narrow, that the hemp store-houses, of three stories high, come close to the spinning-house on either side. These store-houses are capable of containing about 2000 tons of hemp, and the cellars underneath them about 6000 barrels of pitch and tar. The hemp stores in the dock-yard are capable of containing about 2000 tons more.

In the present state and situation of the ropery, it would scarcely admit of the introduction of machinery, as has been done in most of the great private manufactories. The process of tarring, or passing the yarns through heated tar, and then drawing them through apertures in an iron plate, is performed at Woolwich by four horses. The laying of a cable of twenty-two or twenty-three inches is performed by the simultaneous exertion of 170 or 180 men, and requires upwards of an hour of the most severe exertion of strength, especially on the part of those who are stationed at the cranks, who not unusually break a blood-vessel by the severity of the labour. The simple and beautiful machine, invented by the late Captain Huddart, performs with more accuracy the same process, and with the attendance of only three persons.

Woolwich dock-yard seems to be complete in all the usual appendages of artificers, work-shops, store-cabins, offices for the clerks, houses and gardens for the commissioner and the principal officers of the establishment. The number of men employed during the war amounted to about 1800, of whom nearly 1100 were shipwrights and artificers, and the rest labourers. The number of spinners, knitters, layers, labourers, &c. in the ropery, might be about 260. Upwards of twenty teams of horses were daily employed in this yard.

Marines.

One of the four divisions (the 4th, consisting of thirteen companies) of Royal Marines are stationed at Woolwich, where barracks, and all the necessary buildings, have been erected for their accommodation on shore.—(See the article MARINES.)

Chatham Dock-yard.—This dock-yard is situated on the right bank of the Medway, to which it pre-

sents a line of river wall at least 5500 feet in length; the width at the upper end being 400, in the middle 1000, and at the lower end about 800. The superficial contents may be estimated at about 90 acres. It has six building-slips on the front, from which ships are launched into the river; three of these are for ships of the line; and three for frigates and smaller vessels. In the same front are four dry-docks communicating with the Medway.

The inconveniences arising from want of arrangement are less felt in Chatham than in any other of his Majesty's dock-yards; and it could not perhaps be materially improved, if, on the same site, an entirely new dock-yard was to be planned. At the southern extremity of the yard is the ropery, hemp and yarn houses, rigging houses, a range of storehouses, 1000 feet in length, by about 50 in breadth, in front of which, along the wharf, are the anchor racks, extending nearly a thousand feet. Next to these are the slips and docks, with the working-sheds and artificers' shops close in the rear, an excellent smithery, timber-births, seasoning-sheds, deal and iron yard, &c.; and beyond these, on the eastern extremity of the yard, the officers' houses and gardens. The commissioner's house, and excellent garden, are situated nearly in the centre of the yard. The lower, or north-eastern part of the yard, is occupied by mast-ponds, mast-houses and slips, store boat-houses and slips, ballast-wharf, timber-births, and saw-pits.

With all the advantages of interior arrangement, Chatham dock-yard still labours under that great defect to which most of the dock-yards are liable, from the injudicious manner in which the wharf walls have been constructed; without any regard being paid to the ebbing and flowing of the tide, or the currents of rivers, projecting in one part and retiring in others; the consequence of which is, that eddies are formed, and a constant accumulation of mud takes place along the line of the wall, and particularly in the openings of the dry-docks, the slips, and the jetties. Of late years, however, since the attention of engineers has been called to this important subject, every opportunity is taken, in the repair of the wharf walls of the dock-yards, to correct the injurious effects arising from their improper direction; and as the river wall of Chatham is rebuilding, there is no doubt that due attention will be had to the line in which it is to be carried, so as to obviate the evil so universally complained of.

There is no wet-dock or basin in Chatham-yard, but the Medway, flowing along it in a fine sheet of water, in some degree answers the purpose of one. The whole river might indeed be converted into a magnificent basin, by pursuing the same plan as that adopted in forming the new docks at Bristol. This would be effected by cutting a new channel for the river through the chalk cliff below Frindsbury Church, opening out a little above Upnor Castle, and continuing the new channel across the marsh near St Mary's Creek, so as to open out into Gillingham Reach, close to the fort. Here a basin might be constructed wherein ships might be equipped in all respects ready for sea, whenever the wind and tide should be favourable. At present, owing to the shallowness of the water, and the crooked navigation from Chatham round Upnor Point, they are obliged to take in their water and ballast at one place, their stores and provisions at another, their guns, powder, and ammunition at a third; in consequence of which, a ship is usually longer in getting out to sea from Chatham than even from Deptford. If this new channel was made for the river, the whole space from the first reach below Rochester Bridge to St Mary's Creek, at the lower extremity of the dock-yard, might be converted into one magnificent basin.

Chatham, being a building, a repairing, and refitting yard, the establishment of men was much greater in war than Woolwich or Deptford; the number of shipwrights, other artificers and labourers, being upwards probably of 2000, besides that of the rope yard, which might amount to about 250.

A considerable piece of new ground (about 2000 feet in length by 200 in breadth) has recently been added to the upper part of Chatham dock-yard, on which is erected one of the completest saw mills in the United Kingdom, under the direction of Mr Brunell. The mill is situated on high ground, and close to the margin of a deep circular basin or reservoir of water, dug down to the level of the Medway; with which it communicates by a tunnel or subterranean canal, passing through the mast-pond. From the side of the reservoir, opposite to the mill, proceeds a long iron railway, supported on a double row of iron pillars; and alongside of and parallel to this railway, on the side next to the dock-yard, are a continued series of stages for the reception of timber after it has been sawn into plank. A steam-engine, of the power of thirty-six horses, sets in motion all the operations of this mill, which may thus be briefly enumerated: 1*st*, It drags up the large balks of timber through the canal into the reservoir, as they are wanted. 2*d*, It lifts up these large logs to the margin of the basin, carries them into the mill, and places them on the frame under the saws. 3*d*, It saws them with the greatest nicety into planks of any required thickness. 4*th*, It takes the pieces away thus sawn, and places them on carriages of iron. 5*th*, It drives these carriages along the iron railway to any required distance; and, 6*th*, It deposites the sawn timber on the stages, ready to be used, in any part of the dock-yard where it may be required. From these stages it is conveniently conveyed to the docks or slips by single horse carts or trucks, with great expedition, down an easy descent, and without the least interference with any of the works carrying on in the yard. The whole of these operations are conducted by about ten or at most twelve men.

This mill is supposed to be equal to the power of fifty saw-pits and nearly one hundred sawyers, and is capable of supplying the dock-yards of Chatham and Sheerness with all the straight-sawn timber that they can require. But the great advantage of the plan is, in its application of the steam-engine to the management and arrangement of timber, by which the labour and expence of a great number of horses are saved; and, what is of still greater importance,

the obstruction and impediments to the general services of the yard are avoided, which the dragging about of large balks to and from the saw-pits, with teams of four horses each, occasion in all the other yards. It allows, besides, the large space of ground, which these saw-pits would occupy, to be appropriated to other purposes.

Marines.

The first division of Royal Marines, consisting of twenty-one companies, is stationed at Chatham, in excellent barracks, situated near to one of the extremities of the dock-yard. (See art. MARINES.)

Victualling-Yard.

There is a small victualling depot, situated partly in the parish of Chatham and partly in that of Rochester, from whence the ships at Chatham and at Sheerness and the Nore receive a supply of provisions and water; but no articles of ship's stores are manufactured. The store-houses are sufficiently capacious for containing all the stores that can be required for the ships fitted out at the two ports on the Medway. The establishment consists of an agent, clerk of the check, storekeeper, and their respective clerks, which, with the messengers, porters, labourers, &c. may amount to about 90 persons.

Sheerness Dock-Yard.—This dock-yard is situated on a low point of land on the island of Sheppey, whose soil is composed of sand and mud brought from the sea on the one side and down the Medway on the other, and has so much contracted the mouth of this river, as completely to command the entrance of it. The situation, in a military point of view, is a most important one, particularly from its vicinity to the North Sea, and to the anchorage at the Nore; by which anchorage and the works of Sheerness, the mouths of the Thames and the Medway are completely defended.

As a situation for a dock, the objections to which it was liable are now in a fair way of being removed. On account of the low swampy ground on which it stood, fevers and agues were at one time so prevalent, that shipwrights and other artificers were literally impressed and compelled to work at Sheerness. In process of time, however, a town sprung up close to the dock-yard, and with it some little improvement by drainage, embankments, and other measures. Still it continued, till a very short time ago, an unhealthy and disagreeable place. As a dock-yard, it was totally destitute of all convenience or arrangement; and the whole premises mixed among wharfs and buildings belonging to the Ordnance Department, did not exceed fifteen acres of ground. The store-houses were dispersed in various parts of this space, and in so ruinous a state, that a ship hauled up in the mud was by far the best in the whole yard. It had two small inconvenient docks for frigates or smaller vessels. It was, in fact, a mere port of refitment, and might be considered as an appendage to Chatham.

From the very limited capacity of Sheerness, and the mighty preparations in the Scheldt, originated the magnificent project of the naval arsenal at North-fleet, which, from a change of political circumstances, and from the important improvements now carrying on at Sheerness, is not likely ever again to be revived. The Finance Committee (*Eighth Report*) say, they have learnt "that the re-establishment and extension of the yards at Sheerness and Chatham may be considered as superseding, under any circumstance that can now be likely to occur, the plan contemplated for a naval establishment at North-fleet, on so extensive a scale as to require the expenditure of several millions."

Those improvements appear, indeed, to be of that magnitude as to render any establishment at North-fleet wholly unnecessary, by making Sheerness, when finished, as complete a dock-yard, and perhaps more so, than any other in his Majesty's dominions. Previous to carrying into execution this important undertaking, a committee of engineers and others was appointed, among whom was Watt, Huddart, and Jessop, whose plan was afterwards minutely examined, and some slight improvements suggested therein by Mr Rennie. The first stone was laid on the 19th August 1814, and the whole will probably be completed in the year 1822; at an expence not far short of one million Sterling.

The advantages arising from the adoption of this plan are, 1*st*, The addition of nineteen acres of ground to the dock-yard, by taking in the whole of the muddy western shore of the Medway, beyond the low-water mark of neap-tides, and getting rid of the offensive and unwholesome smell which it perpetually occasioned. 2*dly*, The construction of a wet dock or basin 520 feet in length by 300 in width, equal in surface to three and one half acres, and capable of containing a fleet of ten sail of the line, in which they can take on board all their stores, ammunition, and provisions, and be equipped in all respects ready to proceed to sea. The entrance into this basin is from the Medway, through a lock that is closed by a floating dam-gate. 3*dly*, The construction of three dry docks on the eastern side of the basin, and opening into it, each capable of holding a first rate ship of the line. 4*th*, Ample space for constructing store-houses, mast-houses, mast-ponds, and slip, smithery, and artificers' work-shops of every description. 5*th*, A farther extension of the dock-yard, by the addition of ten or twelve acres of a low marshy tract of land called Major's Marsh, which at present is below the level of the sea, and the water kept out, as in Holland, by embankments, but which will be raised several feet by the excavation of the basin, the dry docks, and the mast-ponds, so as to allow of drains to carry off the water to the shore, affording space for timber-births, houses and gardens for all the officers of the dock-yard, as well as for the Admiral Commanding in Chief at Sheerness and the Nore. These additions, together with some part of the premises held by the Board of Ordnance, will make the whole area of the new dock-yard of Sheerness amount to upwards of fifty acres. The wharf wall on the south side of the basin in front of the intended mast-houses is 100 feet, and that on the river front 60 feet in width, lined on both sides with as complete a specimen of good and beautiful masonry of granite as any in the kingdom.

The usual officers with their clerks amounted, during the war, to about 50; and the shipwrights, artificers, and labourers, to about 800; the shipwrights being the most numerous, as the principal

part of the work was confined to the repairing of small vessels in the yard, but mostly to repairs of the fleet afloat at the Nore or in the Medway.

Portsmouth Dock-yard.—Portsmouth dock-yard will always be considered as the grand naval arsenal of England, and the head-quarters or general rendezvous of the British fleet. The dock-yard, accordingly, is by far the most capacious; and the safe and extensive harbour, the noble anchorage at Spithead, the central situation, with respect to the English Channel and the opposite coast of France, and particularly with regard to the naval arsenal at Cherbourg, render Portsmouth of the very first importance as a naval station; and, in this view of it, every possible attention appears to have been paid to the extension and improvement of its dock-yard. The sea wharf-wall of this yard, extending in the direction of north and south along the western shore of the harbour, is about 3500 feet in length; and the mean depth may be 2000 feet, and it incloses an area of more than one hundred acres.

In the centre of the wharf-wall, facing the harbour, is the entrance into the great basin, whose dimensions are 380 by 260 feet, and its area $2\frac{1}{5}$ acres. Into this basin open four excellent dry-docks, and on each of its sides is a dry-dock opening into the harbour; and all of these six docks are capable of receiving ships of the largest class. Besides these is a double dock for frigates, the stern dock communicating through a lock with the harbour, and the head dock with another basin about 250 feet square. There is also a Camber, with a wharf-wall on each side 660 feet in length, and of sufficient width to admit of transports and merchant ships bringing stores to the dock-yard. In the same face of the yard are three building-slips capable of receiving the largest ships, and a small one for sloops, besides two building-slips for frigates on the northern face of the yard, and a smaller slip for sloops. The range of store-houses on the north-east side, and the rigging-house and sail-loft on the south-west side of the Camber, are magnificent buildings, the former occupying nearly 600 feet in length, exclusive of the two intermediate spaces, and nearly 60 feet in width, and the two latter 400 feet. The two hemp-houses and the two sea-store houses occupy a line of building, which, with the three narrow openings between them of 25 feet each, extend 800 feet. The rope-house, tarring-house, and other appendages of the ropery, are on the same scale. The two sets of quadrangular store-houses, and the two corresponding buildings, with the intervening timber-births and saw-pits, at the head of the dry-docks, issuing from the great basin, are all excellent and conveniently placed. The smithery is on a large scale, and contiguous to it is an iron-mill, a copper-mill, and a copper refinery, at which is remelted and rolled all the old copper which is taken from ships' bottoms; and here, also, are cast bolts, gudgeons, and various articles of copper used in the navy. The number of sheets manufactured in one year of the war amounted to about 300,000, weighing above 12,000 tons, on which it has been calculated that a saving of at least L. 20,000 was effected for the public, besides obtaining a good pure article. Most of these were constructed under the direction of General Bentham. (Bentham's *Services*, &c.) At the head of the north dock are the wood mills, at which every article of turnery, rabitting, &c. is performed for the use of the navy, from boring the chamber of a pump to the turning of a button for a chest of drawers. But the principal part of these mills is the machinery for making blocks, contrived by that ingenious artist Mr Brunell (see BLOCK-MACHINERY), which cannot be regarded without exciting the highest respect for the talents and skill of the author.

The northern extremity of the dock-yard is chiefly occupied with seasoning-sheds, saw-pits, and timber-births,—the working boat-house, and boat-store-house. On the eastern extremity are situated the houses and the gardens of the Commissioner and principal officers of the yard; the chapel, the royal naval college, and the school of naval architecture. The former institution has recently been remodelled, and the latter is a new establishment formed by the recommendation of the Commissioners for revising the civil affairs of the navy, for the education of a certain number of naval architects, known by the name of the "Superior class of Shipwright Apprentices." These two establishments were combined, by order in Council of the 30th January 1816, under the following regulations:

Naval College.

Naval College.—The number of students not to exceed, in time of war, one hundred; in peace, seventy; of whom thirty are to consist of the sons of commissioned officers of the navy, and to receive their board, clothing, lodging, and education, free of all expence; the remainder to consist of sons of noblemen, gentlemen, civil and military officers, on payment of L. 72 a-year. The age of admission from $12\frac{1}{2}$ to 14 years. A bond is to be signed by their friends, in the penalty of L. 200 for the first class, and L. 100 for the second class, in the event of any young gentleman being withdrawn from the navy before he has served the proper time to qualify for the commission of lieutenant. (See article NAVY.) No student to remain at college longer than three years; at the end of which, or sooner, if he shall have completed the plan of education, he is discharged into one of his Majesty's ships, the college time being reckoned two years of the six required to be served to qualify for such commission.

Naval Architectural School.

Naval Architectural School.—The number of students not to exceed twenty-four. Candidates for admission examined at stated periods, the degree of merit alone giving preference for admission; the age of entrance from 15 to 17, and the duration of their apprenticeship seven years. The students are lodged, boarded, and educated, free of all expence, and have the following yearly allowances: 1st year L. 25, 2d L. 30, 3d L. 35, 4th L. 40, 5th L. 45, 6th L. 50, 7th L. 60. And at the expiration of their apprenticeship they are eligible to all the situations in the ship-building department of his Majesty's dock-yards, to be there employed as supernumeraries, until regular vacancies may occur; provided the apprentice shall have completed the plan of education, and certified by the professor to be properly qualified.

The consolidated establishment of the two departments consists of a governor, who is the first

 Lord of the Admiralty for the time being; a lieutenant-governor, who is a post-captain in the navy, with a salary of L. 800 a-year, and apartments; two lieutenants of the navy with L. 200 a-year each, apartments, and an allowance for board. A professor, who is a graduate of the University of Cambridge, with a salary of L. 700 a-year, and apartments; a master of classics, history, and geography, with L. 350 a-year, and apartments; three assistant-masters, well skilled in mathematics, the first with L. 250, the two others L. 200 a-year each, with an allowance for house-rent; besides masters for teaching drawing, dancing, fencing, and the French language, and two serjeants of marine artillery. In addition to which, is a superintendent of the school for naval architecture, a professional ship-builder, brought up in one of his Majesty's dock-yards, to instruct the apprentices in the practical part of ship-building.

The professor has the charge, and keeps the rate of all the chronometers, which may not be in use, belonging to the navy; and all midshipmen in the navy are now required to pass their examination in the theory of navigation, at the naval college, by the professor, in presence of the admiral commanding in chief, and the lieutenant-governor. (See NAVY.)

The strength of Portsmouth dock-yard, during the war, was considerably above 4000 working men, of which about 1500 were shipwrights and caulkers; the joiners and house carpenters were nearly 500; the smiths 200 nearly; the sawyers 250; the riggers and their labourers nearly 200; and scavelmen and labourers of various kinds nearly 700; and the rope-yard employed about 350 persons.

Portsmouth Victualling Establishments.

There are two victualling establishments at this port; the one in Portsmouth town, the other across the harbour, at a place called Weevil; both of them inconveniently situated for supplying the ships with water and provisions, more especially such as may have to take them in at Spithead. The former consists chiefly of provision-stores and magazines, with a tide-mill and a bakery; at the latter there is a cooperage and a brewery. The total number of persons employed, including the officers, at the two establishments, during the war, amounted to about 500.

Haslar Hospital.

The noble building for the reception of sick and wounded seamen is situated on the Gosport side of Portsmouth harbour. Being appropriated to the military branch of the navy, it will be described under the head of NAVY.

Marines.

The second division of Royal Marines, consisting of eighteen companies, are stationed at Portsmouth, in barracks, which are inconveniently situated in the town; and eight companies of the Royal Marine Artillery have their head-quarters at Fort Monckton, not far from Haslar Hospital. (See the art. MARINES.)

Plymouth Dock-Yard.

Plymouth Dock-Yard.—The naval station of Plymouth is inferior only to that of Portsmouth; and, in point of its more westerly situation, as considered with reference to the grand naval arsenal of Brest, it is superior even to Portsmouth. It possesses one of the finest harbours in the world, capable of containing, in perfect security at their moorings, not less than a hundred sail of the line; and, when the Breakwater shall be completed, it may then boast of an excellent roadstead for eighteen or twenty sail of the line. The dock-yard, however, has only one small basin, without gates, whose dimensions are 250 by 180 feet, and contents little more than an acre; but the excellent harbour of Hamoaze, on the western bank of which the wharf wall extends, almost compensates for the want of one, especially as the depth of water allows the largest ships to range along the jetties, and receive their stores on board immediately from the wharf.

Plymouth dock-yard extends in a circular sweep along the shores of Hamoaze 3500 feet, its width about the middle, where it is greatest, being 1600, and at each extremity 1000 feet, making its superficial contents about 96 acres. In the line facing the harbour are two dry-docks for ships of the first rate, a double dock for 74 gun ships, communicating with Hamoaze, and another dock for ships of the line, opening into the basin. There is, besides, a graving-dock without gates, and a canal or camber similar to that in Portsmouth yard, for the admission of vessels bringing stores into the yard; which, communicating with the boat-pond, cuts the dock-yard nearly into two parts. There are five jetties projecting from the entrances of the dry-docks into Hamoaze, along side of which ships are conveniently brought when undocked. All these are situated between the centre and the northern extremity of the harbour line. On the southern part are three building slips for the largest class of ships, and two for smaller vessels, the outer mast-pond and mast-houses, timber-births, saw-pits, and smithery. Higher up, on this end of the yard, is an extensive mast-pond and mast-locks, with plank-houses over them; and, above these, three hemp magazines, contiguous to which is the finest ropery in the kingdom, consisting of two ranges of buildings, one the laying-house, the other the spinning-house, each being 1200 feet in length, and three stories in height. In the construction of the new rope-house no wood has been used, excepting the shingles of the roof, to which the slates are fastened. All the rest is of iron. The ribs and girders of the floors are of cast iron, covered over with Yorkshire paving stone, and the doors, window frames, and staircases, are all of cast iron, so that the whole building may be considered as proof against fire.

The northern half of the yard, besides the docks and basin, with all the appropriate working sheds and artificers' shops, contains a cluster of very elegant stone buildings, ranged round a quadrangle, the longest sides being about 450 feet, and the shortest 300 feet. Within the quadrangle are also two new ranges of buildings, in which iron has been used in the place of wood. These buildings consist of magazines for different kinds of stores, rigging-houses, and sail-lofts. The northern and upper part of the yard is occupied by a range of handsome houses, with good gardens behind them, for the commissioner and the principal officers of the yard, the chapel, the guard-house, and pay-office, stables for the officers, and the teams, and a fine reservoir of fresh water for the supply of the yard.

Plymouth is not only a good building and repairing yard, on account of its excellent docks and slips, and the great length of line along the Hamoaze, but

Dock-Yards. also a good refitting yard, and was fully occupied during the war with the refitment of the western squadron, employed in the constant blockade of Brest. The number of men borne on the establishment of this yard might have been about 3000, of which about 800 were shipwrights.

Plymouth Victualling Establishments.

Plymouth Victualling Establishments.—The victualling establishments are here, as well as at Portsmouth, unconnected, and, in fact, dispersed in three different places: the cooperage and the brewery being at South-Down, near Mill-brook, on the farther side of Hamoaze; the bake-house and principal stores at the entrance of Sutton-Pool, in the Catwater, and the slaughter-house on the Devil's Point at the head of the Sound. The total establishment of the victualling department at this port, officers included, amounted to about 400 persons.

Plymouth Hospital.

Plymouth Hospital—Is a handsome building of stone, or rather a series of separate buildings, regularly arranged, in which respect, as admitting a freer circulation of air, it is perhaps superior to that of Haslar. (See NAVY.)

Marines.

The third division of Royal Marines, consisting of 20 companies, are stationed at Plymouth. The barracks are conveniently situated at Stonehouse, very airy, and sufficiently spacious. (See MARINES.)

Pembroke Dock-yard.

Pembroke Dock-Yard.—This dock-yard has been established but a very few years, and is intended merely as a building-yard. It is situated on the southern shore of Milford Haven, not two miles from the town of Pembroke. It includes an area of about 60 acres, its surface descending in a gradual slope to the water's edge, along the shore of which is ample space for a couple of dry-docks, and at least twelve building slips, over which it is intended to erect a connected series of roofs, which will not only be attended with much convenience to the workmen, but also with a great saving of expence. The slips, being built of wood, on a limestone foundation, are erected at a very trifling cost; and the only works of any considerable expence in the yard, will be that of the dry-docks, each of which will amount to the sum of L. 60,000 nearly. For a new building-yard, a small store-house will be quite sufficient, and an old ship hauled up, serves all the purposes of one at present. There is no commissioner, nor is the usual establishment of officers completed. The total number of persons of all descriptions employed in the yard are under 500.

Ordinary of the Dock-yards.

Ordinary of the Dock-Yards.—At each of the ports where there is a dock-yard (Pembroke excepted), a certain number of ships when put out of commission, or new ships not yet commissioned, are laid up in what is called a state of ordinary, and such ships, till very recently, used to be placed under the immediate charge of the commissioner, the masters attendant, and other officers of the dock-yard. But a new system has lately been adopted, both with regard to the fitting of the ships for their better preservation, while thus unemployed (DRY ROT), and also as to the care and management of them by naval commissioned officers living constantly on board. (See NAVY.)

Capacity of a Dock-yard.

Capacity of a Dock-Yard.—The capacity of a dock-yard for building, repairing, and refitting ships of war, depends upon so many circumstances, that it scarcely admits of calculation; chiefly, however, on the facilities afforded by a suitable arrangement of dry-docks, building slips, and basins, and on the number of shipwrights and other artificers borne on the strength of the yard. In building new ships, where the materials are at hand, and no interruptions occur, the capacity may be ascertained to a tolerable degree of accuracy. To complete the building of a 74 gun-ship, it is calculated that the labour of one man would be required for 18,000 days, or of 18 men for 1000 days, or about 54 men to finish her in one year. A dock-yard, therefore, with 500 good shipwrights, might be expected to launch from eight to ten sail of the line every year, if the conveniences of the yard admitted them all to be employed on building. But with regard to repairs, they are so various and so uncertain, that it would be next to impossible to form any calculation that should at all approach to the truth. A writer, well-versed in naval matters, in attempting to prove the sufficiency of our dock-yards, without having recourse to private merchant yards during war, has stated, that by an uniform system of management, "the annual regeneration of ships of the line may be safely reckoned at *twelve sail*, and that of frigates at *eight sail*;" and that besides, there "might be docked for casual repairs, in the course of one year, *two hundred and sixty-seven sail* of ships and vessels of war." (*Letter to Lord Melville on the General State of the Navy*, 1810.)

Management of the Dock-yards and other concerns of the Navy.

When Henry VIII. first established a regular king's dock-yard at Woolwich, he appointed a board, consisting of certain commissioners, for the management of all naval matters; and it is curious enough, as appears from the *Pepysian Collection of Manuscripts* in the University of Cambridge, that the regulations which he made for the civil government of the navy, and which were, in the reign of Edward VI., revised, arranged, and turned into ordinances, form the broad basis of all the subsequent instructions given to the several officers, to whom the management of the civil affairs of the navy has been committed. (*First Rep. Nav. Rev.*)

Commissioners of the Navy.

The Commissioners of the Navy then consisted of the Vice-Admiral of England, the Master of the Ordnance, the Surveyor of the Marine Causes, the Treasurer, Comptroller, General Surveyor of the Victualling, Clerk of the Ships, and Clerk of the Stores. They had each their particular duties; and once a-week they were ordered to meet at their office on Tower Hill, and once a month to report their proceedings to the Lord High Admiral.

In 1609 the principal officers for conducting the civil affairs of the navy were suspended in consequence of many abuses being complained of; and other commissioners were appointed, with powers to manage, settle, and put the affairs of the navy into a proper train, and to prevent, by such measures as might appear to be necessary, the continuance of the many great frauds and abuses which had prevailed. A similar commission was renewed in 1618, which in a full and minute report detailed and explained those frauds and abuses.

That commission, which ended on the death of James I., was renewed by his successor, and remained in force till 1628, when it was dissolved;

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and the management of the navy was restored to the Board of Principal Officers, as established by Edward VI.

In the disturbed reign of Charles I., the navy was suffered to go to decay; but by the extraordinary exertions of Cromwell, it was raised to a height which it had never before reached; but again declined under the short and feeble administration of his son.

Duke of York the Lord High Admiral.

On the restoration of Charles II., the Duke of York was appointed Lord High Admiral; and by his advice a committee was appointed to consider a plan he had drawn out for the future regulation of the affairs of the navy, at which he himself presided. "In all naval affairs," say the Commissioners of Revision, "he appears to have acted with the advice and assistance of Mr Samuel Pepys, who first held the office of Clerk of the Acts, and was afterwards Secretary of the Admiralty; a man of extraordinary knowledge in all that related to the business of that department, of great talents, and the most indefatigable industry."

The entire management of the navy was now in the hands of the Duke, as Lord High Admiral, by whom three new commissioners were appointed to act conjunctly with the Treasurer of the Navy, the Comptroller, the Surveyor, and Clerk of the Acts, as Principal Officers and Commissioners of the Navy; a book of instructions, drawn out by Mr Pepys, was sent to the Navy Board for its guidance; a rapid progress was made in the repair and augmentation of the fleet; but being called away, in consequence of the Dutch war in 1664, the example of zeal and industry set by Mr Pepys was not sufficient, in the Duke's absence, to prevent neglect and mismanagement in every department except his own.

New Set of Commissioners.

From 1673 to 1679, the office of Lord High Admiral being put in commission, at the head of which Prince Rupert was placed, the King, by Mr Pepys, arranged all naval affairs; but in the latter year, when the Duke was sent abroad, and Mr Pepys to the tower, a new set of men were made commissioners of the navy, who, without experience, ability or industry, suffered the navy to go to decay. "All the wise regulations," say the commissioners of revision, "formed during the administration of the Duke of York, were neglected; and such supineness and waste appear to have prevailed, as at the end of not more than five years, when he was recalled to the office of Lord High Admiral, only 22 ships, none larger than a fourth rate, with two fire-ships, were at sea; those in the harbour were quite unfit for service; even the 30 new ships which he had left building had been suffered to fall into a state of great decay, and hardly any stores were found to remain in the dock-yards." He reappointed Mr Pepys as Secretary of the Admiralty; he set about an inquiry into the characters and abilities of the first ship-builders in England, and by the advice of Mr Pepys, joined Sir Anthony Dean, eminent in that profession, with three others, to the former principal officers, in a new commission. The old commissioners were directed entirely to confine their attention to the business of a committee of accounts. To each of the new ones was entrusted a distinct branch of the proposed reform; and it appears, that, highly to their credit, "they performed what they had undertaken, in less time than was allowed for it, and at less expence;" having completed their business to the general satisfaction of the public, two months before the Revolution.

The business of the navy, thus methodized and settled, remained undisturbed by that event. The commissioners of revision justly observed, that "the great work of re-establishing the fleet, and restoring order, industry, and discipline, in the dock-yards, accomplished in so short a time by the commissioners then chosen, with so much care, proves, in the most convincing manner, how much depends on having the civil affairs of the navy placed under the management of men of real ability, professional knowledge, and uninterrupted industry."

Commissioners of Naval Inquiry and Revision.

It will readily be supposed, that the vast increase of our naval force since that time, has necessarily required many additional orders and regulations, some of which, from circumstances, are not compatible with each other; some given to one dock-yard and not to another; others in one yard became obsolete, while they continued to be acted upon in another; so that there was no longer that uniformity in the management which it is so desirable, indeed so essentially necessary to preserve. From the year 1764 to 1804, when his Majesty appointed a commission "for revising and digesting the civil affairs of his navy," the attention of the Lords of the Admiralty and the Navy Board had frequently been directed to this important subject; but owing to various causes, nothing was done to forward so desirable an arrangement, except that Sir Charles Middleton (afterwards Lord Barham), when comptroller of the navy, classed and digested under distinct heads, in a book for that purpose, all orders and regulations prior to the year 1786. The commissioners of naval inquiry, appointed in 1803, state the necessity of revising the instructions, and digesting the immense mass of orders issued to the dock-yard officers, and regret that a work of such utility should not have been completed. The late Lord Melville, to whom the navy is perhaps more indebted than to any single individual, and who, from the active part he had long taken in its concerns, was well aware of the irregularities and disorder which prevailed in the dock-yards, on his appointment to the administration of naval affairs, determined to carry into execution a complete system of reform and of uniform management, in all the several departments. The commission consisted of Admiral Lord Barham, John Fordyce, Esq. Admiral Sir Roger Curtis, Bart. Vice Admiral Domett, and Ambrose Serle, Esq. They made fifteen distinct reports; the date of the first being June 13th, 1805; of the last, the 6th March 1808; all of which except two have been printed, by order of the House of Commons, and mostly carried into effect by his Majesty's Orders in Council. One of the two not printed, is an inquiry into the state of the navy at different periods, and of naval timber; the other relates to the formation of a new dock-yard at North-fleet, which, however advisable and even necessary the design of it might have been considered, at the time when Bonaparte was energetically carrying on his mighty plans, for the creation of a naval force to contest the power of

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the ocean with Great Britain, will, as has already been observed, no longer be thought so, under present circumstances.

Uniform System of Management introduced.

From these reports have been established, for the first time, in all his Majesty's dock-yards, one uniform system of management, by which incalculable advantages are said to have been derived to the public, in the preventing of frauds, in the saving of labour and materials, and consequently time and expence, and in securing better workmanship in the construction of ships, which is perhaps of all other considerations the most important.

Commissioners of the Navy.

The management of the dock-yards, and of all the civil affairs of the navy, is entrusted to certain commissioners appointed by patent, of whom the comptroller of the navy and three surveyors, and seven other commissioners, form a board at Somerset House, for the general direction and superintendence of the civil concerns of the navy, subject to the control of the Lords Commissioners of the Admiralty. At most of the home yards and of the foreign yards is a commissioner of the navy, who is always a naval officer, of the rank of post-captain. The foreign yards, over which a commissioner presides, are Bermuda, Cape of Good Hope, Gibraltar, Halifax, Jamaica, Malta, Quebec, Kingston, including the lake-establishments, and Trincomallee, which, with the five belonging to the home yards, Woolwich (including Deptford), Chatham, Sheerness, Portsmouth, and Plymouth, make the whole number of commissioners of the navy amount to twenty-four. The salary of each of the Home Commissioners is L. 1000 a-year; that of the Comptroller L. 2000. The salary of the Foreign Commissioners L. 1200 a-year, except that of the Cape of Good Hope, which is L. 1800, and Trincomallee which is L. 3000 a-year. They are also entitled to very liberal superannuations when unfit for further service; and at their death, their widows receive a pension for life of L. 300 a-year.

Establishment of Navy Office.

The establishment of the navy-office at Somerset House consists of eleven commissioners; a secretary and assistant secretary; two secretaries to the committees of accounts and stores; an assistant to the surveyors; a receiver of fees and paymaster of contingencies; and 150 clerks with salaries from L. 800 to L. 90 a-year, besides a surveyor of buildings and six draughtsmen, messengers, porter, &c.—the total annual expence of which, as voted by Parliament in 1817, amounted to L. 77,504, 18s. 6d.—*(Ordinary Estimate of the Navy.)*

Of the Treasurer's Office.

The treasurer of the navy is a high and responsible officer, appointed by the crown, and removeable at pleasure. His salary was L. 4000 a-year, but has recently been reduced to L. 3000. The establishment of the navy pay-office at Somerset House consists of a paymaster and deputy, three cashiers, one for the navy, one for the victualling, and one for the allotment branch; an accountant, inspector, a superintendent of the payments of the dock-yards, resident in London, sixty established and eighteen extra clerks, besides six pay clerks and three conductors of money at the four pay-ports, Portsmouth, Plymouth, Chatham, and Sheerness. The annual expence of this establishment, as appears from the navy estimates of 1817, amounts to L. 43,241, 15s. 4d.—*(Ordinary Estimate.)*

Victualling Establishment.

To each of the four dock-yards, Deptford, Portsmouth, Plymouth, and Chatham, are victualling establishments for supplying the fleet with provisions and water; and also at Dover, Cork, Cape of Good Hope, Gibraltar, and Malta. There is no resident commissioner at any of the victualling establishments, either at home or abroad; but the superintendent of the victualling-yard at Deptford, which is the great depot of provisions for the fleet, is a post-captain in the navy. At each of the others, the duty of providing, and of issuing provisions to his Majesty's ships, is entrusted to an officer named the "Agent Victualler." The victualling of the navy was formerly under the direction and superintendence of the navy board; but at length the navy increased to such a magnitude as to render a separate establishment necessary, to which the furnishing of all supplies of provisions, both at home and abroad, should be entrusted, subject to the control of the Lords Commissioners of the Admiralty. The victualling board at Somerset House consists of a chairman and deputy-chairman, the former with a salary of L. 1200, the latter of L. 1000 a-year, and five other commissioners with salaries of L. 800 a-year each; a secretary to the board, and a secretary to the committee of accounts; a registrar of securities, and 136 clerks, with salaries varying from L. 800 to L. 80 a-year, according to their class and length of service, the total annual expence of which amounted, in 1817, to L. 45,541, 13s. 4d.

The Commissioners of Victualling are also allowed to retire on superannuations when unfit for service, and discretionary pensions settled on their widows and children.

The Transport Board having been dissolved at the end of the war, its twofold duties were divided between the Navy and Victualling Boards; those which concerned the hiring of transports devolved on the Commissioners of the Navy, and those which related to the sick and hurt department, on the Commissioners of the Victualling Board, on whom also devolves the direction and superintendence of all the naval hospitals at home and abroad.

Officers of the Dock-yard, and their respective Duties.

The principal officers of an established dock-yard are, 1. The commissioner. 2. The master attendant. 3. The master shipwright. 4. The clerk of the check. 5. The store-keeper. 6. The clerk of the survey; to which have recently been added the subordinate officers of timber-master, and the master measurer. There are besides several assistants to the master attendant and master shipwright, foremen, sub-measurers, quartermen, and converters, surgeon, chaplain, boatswain, warden, &c. The enumeration of the establishment of salary-officers of one yard, Portsmouth, for instance, will serve to convey a general idea of the whole.

1. The Commissioner's salary L. 1100 a-year (all others L. 1000); three clerks with salaries from L. 400 to L. 120.

2. Two masters attendant, one at L. 650, the other at L. 500 a-year; one clerk to both.

3. Master shipwright, L. 720 a-year, three clerks from L. 300 to L. 120.

4. Clerk of the check, salary L. 600; eight clerks from L 400 to L. 80.

5. Storekeeper, salary L. 600 a-year; twelve clerks from L. 400 to L. 80.

6. Clerk of the survey, L. 500; eight clerks from L. 400 to L. 80.

7. Clerk of the rope yard, L. 350; one clerk.

8. Engineer and mechanist, L. 600 (at Portsmouth only), with a draughtsman; one clerk.

9. Timber master, salary L. 500; seven clerks from L. 250 to L. 80.

10. Three assistants to the master attendant at L. 220 each; one assistant to the timber-master, L. 200; three assistants to the master shipwright, L. 400 each.

11. The master-measurer, L. 250 a-year; ten clerks from L. 200 to L. 80.

12. Thirty-five foremen from L. 250 to L. 80 each.

13. Sub-measurers, quartermen, and converters, from L. 180 to L. 160 each.

14. The master mast-maker, sail-maker, boat-builder, joiner, house-carpenter, brick-layer, smith, ropemaker, rigger, painter (wood-mills, metal-mills, mill-wright, at Portsmouth only); with salaries each, from L. 260 to L. 200 a-year.

15. 22 Cabin-keepers from L. 100 to L. 60 each.

16. A surgeon, L 500; assistant L. 200.

17. Chaplain, L. 500.

18. Boatswain, L. 250.

19. Warden of the gate, L. 200.

Watchmen, warders, and rounders.

The total amount of the salaries paid to the above mentioned officers in the year 1817, in Portsmouth yard alone, was L. 50,065, 5s. (*Estimates of the Ordinary of the Navy*, 1817.)

The duties of these several officers may briefly be summed up as under:

Commissioner.

The Commissioner has full authority over all officers and other persons employed in the dock-yard and ordinary; can suspend any officer until the decision of the Lords of the Admiralty or Navy Board shall be taken; sends a daily report of transactions relating to the shipping, to the Admiralty, and another more detailed report of the transactions of the yard, to the navy office; he is to see that the officers of the several departments be diligent and attentive to their respective duties; to visit the storehouses, and examine the stores received from the contractors; to use every means for preventing embezzlement of stores; to examine any ship or vessel meant to be purchased or hired, to see that she is fit for the service intended; to superintend the general monthly muster of all the men belonging to the yard, and to the ordinary once each quarter; to control the quarterly payments of the yard, and of all ships where there is no pay-captain specially appointed for that service; to co-operate with the commander in-chief, captains, and officers of his Majesty's ships in commission; and, generally, to adopt such regulations and instructions for the management of the yard as may appear to be most expedient for the benefit of the public service.

Master Attendant.

Master Attendant.—The duties of this officer are highly important both in the dock-yard and afloat. Of that part of the latter, however, which gave him the responsibility for the general care and management of the ships in ordinary, he has been relieved by recent regulations, in consequence of the ordinary being placed under the superintendence of commissioned officers of the navy. He has still, however, to take care that the iron ballast of ships laid up in ordinary be ready for sea service; that the ships have on board a proper quantity of shingle ballast to keep them down to a proper depth in the water; that the ships be arranged at their moorings according to their respective draughts of water; to see that when any ship is put in commission, the iron ballast be stowed according to the established plan; to see that the moorings are of a proper size; to lay them and the transporting buoys down, and to take care that they are kept in a proper state of repair; not to permit any merchant vessel to lie at them, or alongside of the ships in ordinary; that no strange boats loiter about the ships, or wharfs, or jetty-heads. He is to attend the docking, grounding, and graving all of his Majesty's ships, by day or night; to take charge of them while transporting from and to their moorings; to give assistance to all ships in distress, within the limits of the port and neighbourhood; to appoint craft for the conveyance of stores to or from his Majesty's ships, all the sailing and other craft belonging to the yards being under his directions; to survey all ships tendered to Government, in company with the master shipwright and clerk of the survey; he is to keep an account of the entry and discharge of all sailmakers, riggers, and riggers-labourers, employed in his department of the yard, whom he is to examine as to their qualifications; to visit frequently the sail-loft and rigging-house, and, in conjunction with the master, sail-master, and master-rigger, settle the work that is to be done on every succeeding day; he is carefully to inspect the qualities and dimensions of all stores with the storekeeper and the respective masters of the trades, rejecting all such as may not be agreeable to contract. He is to take care to provide rigging and stores in due time, for every ship that shall be ordered to be brought forward for commission; he is to join the clerk of the survey in warranting all stores demanded for a ship refitting; to examine all the boatswain's stores landed from a dismantled ship; and all sails, cables, cordage, and other old stores, before they are delivered into the charge of the storekeeper; and, in company with the storekeeper, frequently to examine the state of the stores. These, and numerous other duties connected with the receipt and expenditure of stores, and the distribution of the labour of a very considerable proportion of the strength of the yard, fall to the lot of the master attendant, who is always selected from among the old and experienced masters in the navy.

Master Shipwright.

Master Shipwright—Has the superintendence of all ships ordered to be built, repaired, and refitted; is ordered to be present at the launching, docking, and undocking, grounding, and graving of all ships; the disposal of all the shipwrights, caulkers, house-carpenters, joiners, &c. ashore and afloat, the examination of them when entered on the yard; has the sole direction of the boatswain of the yard, of the mast-makers, boat-builders, capstan and top-makers, and

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generally all such as are employed on wood-work. All the carpenters of ships in ordinary are under his directions; all the timber of the yard is at his disposal; and the timber-master, who is more immediately charged with the management of the timber, as to its arrangement, conversion, &c. is to follow the direction of the master-shipwright. He keeps an account of the expences of the repairs and refitment of ships, as well as of ships building. and assists in preparing the Parliamentary estimates for the extraordinaries of the navy in each year. He attends the surveys of ships coming in from sea, and reports the nature of their defects, and when a ship is brought forward for service from a state of ordinary, he estimates the expence and the time that may be required to fit her for sea. From the master shipwrights are selected persons to fill the important situation of "Surveyor of the Navy."

Clerk of the Check.

Clerk of the Check—Is an officer of great trust, and charged with many important duties. He keeps an accurate account of the entry and discharge of every man in the yard; musters them either himself or by his clerks, every time they pass the gates, into or out of the yard, and checks those that may be absent; keeps an account of the pay earned by every man; musters the ordinary once a month, and every ship in commission at the port at uncertain times; also the crews of all tenders, store-ships, navy transports, and other hired vessels, and all ships belonging to the public service, immediately on their arrival in port. He attends the receipt of all stores, articles, and materials of every kind delivered into the yard, and examines with the proper officers all works performed by contract; takes an account of all stores received as a check upon the storekeeper; of hemp, tar, and other materials for the rope-yard, as a check on the clerk of the rope-yard; receives the money produced by the sales of old stores or chips, and pays the contingent expences of the yard; attends all the payments of the yard and the ordinary; pays bounty and conduct money; and at the end of every quarter furnishes the Navy Board with complete copies of all his accounts.

Storekeeper.

Storekeeper.—This officer has the charge of all the storehouses in the yard, and stores of every description, as well manufactured articles as raw materials, with the exception of timber and hemp, which are in charge of the timber-master and clerk of the rope-yard respectively, until manufactured, when they are also delivered over to the storekeeper. Attended by the clerk of the check, the clerk of the survey, and the other respective officers and masters of the trades, he carefully inspects the qualities and dimensions of all articles received into the yard, and rejects all such as may not be agreeable to contract, or abates of the price or quantity according to any deficiency that may appear; each species is then entered in a rough book, and, when checked and examined, is brought into the ledger. He has the sole charge of all slops, beds, bedding, and marine clothing; but he is not charged with old stores returned into the yard, such as sails, cables, copper, &c. until the master attendant, or master-shipwright, in their respective departments, have examined and charged him with them, by a note under their hands. At the end of every quarter he transmits to the Navy Office all the rough receipt books, vouchers of receipts, and issues, with a correct abstract, and a quarterly balance of stores on hand.

The stores belonging to each ship at the port are kept in their proper store-births, and marked with the ship's name to which they belong; and when a ship is to be brought forward for commission, all her stores are immediately placed in the birth belonging to the ship. All stores are marked by the storekeeper with the broad arrow, the distinguishing mark of the king's stores. The difficulty of examining the immense quantity of certain articles of stores, operated at one time against any examination whatever; and it generally happened, on the appointment of a new storekeeper, that the quantities in store differed very materially with the balances in the ledger; but, of late years, this evil has been remedied by obliging the storekeeper to compare the quantities on hand with the balance in his books, whenever any species of store shall be reduced so low as to admit of its being done without inconvenience to the public service. It is obvious that, although every practicable check has been adopted on the receipts and issues of the storekeeper, that this officer is charged with a high and responsible situation of trust.

Clerk of the Survey.

Clerk of the Survey.—The duties of this ancient officer were probably at one time more important than they now are, though he is still charged with a great variety of business, connected chiefly with the store department, on which he is the main check, especially as far as regards the issues of stores to ships in commission, and the returns when put out of commission. He keeps an account of the stores issued to each person, and charges him with the same. He takes a monthly survey of the remains of stores issued for the annual service of the yard. He is to see that the quantity of stores issued to ships when put in commission or when refitting, is conformable with the establishment, and that each ship has neither more nor less than her exact proportion; and he is to supply her commander with a complete survey-book, containing the dimensions of her masts, and yards, and sails, size and length of rigging, blocks, &c and an account of all the stores committed to the charge of the boatswain and carpenter, whose expence-books are examined, together with the remains, on her return to port, by the clerk of the survey. On the death or removal of a storekeeper, the clerk of the survey, in conjunction with the newly appointed successor, and such others as may be appointed, is to take a complete survey of all the stores in the yard, in order that the new storekeeper may be regularly charged therewith, and become responsible for the same. These are the principal duties; but there are many others which the clerk of the survey has to perform, and which require his constant and unremitting attendance.

Clerk of the Rope-Yard.

Clerk of the Rope-yard has the charge of the ropery, and all the store-houses belonging to it, and musters all persons employed in the rope-yard every time they come in to work, and in the evening when they leave work. He attends the receipt of all stores for his department, in which he is checked by a clerk from the Clerk of the Check's Office, and another from that of the Clerk of the Survey;—he attends all payments of the rope-yard, and transmits quar-

Dock-Yards. terly accounts to the Navy Board.—(*First Report of the Commissioners for revising the Civil Affairs of the Navy.*)

Engineer and Mechanist. *Engineer and Mechanist.*—This officer is of recent appointment, and is borne on the establishment of Portsmouth Dock-yard only; the wood and metal mills, and the block machinery, being confined to that yard; and they require a person of great skill and judgment, not only to keep them in order, but to suggest improvements, and to examine any new invention in mechanics that may be proposed for his Majesty's service in any of the dock-yards.

Timber-Master. *Timber-Master.*—This officer is also of recent appointment. Formerly all timber received into the yard was placed under the charge of the store-keeper, and under the management of the master shipwright and his assistants; the one having no professional knowledge, and the other little or no responsibility while in its rough state. The difficulty of procuring a supply of certain descriptions of timber, and the ravages committed by the dry-rot, have effected a change in the charge and management of this important article highly advantageous to the public service. The timber-master is now the responsible person; and, in consequence of which, more care and attention are bestowed in the classing, stacking, and keeping an accurate account of the receipt and expenditure of timber, than at any former period. Though thirty or forty thousand loads may be in a dock-yard at one time, every single log or balk is marked, numbered, and assorted in so methodical a manner, that any individual piece can, at a moment's notice, be pointed out; and where the master shipwright may demand a piece of timber for some particular purpose, the stack is immediately pointed out where such piece is to be found. To preserve this arrangement—to examine all the timber as it comes into the yard—to keep the account of the receipts and expenditure, with all the various duties attached to this office, require a number of clerks, who are constantly employed under the timber-master.

Master-Measurer. *Master-Measurer.*—This officer likewise presides over a department but recently created: and, with the *Foremen, Sub-measurer, Quarter-men*, &c. forms a large addition to the number of salary-officers in the dock-yards; but the appointment was deemed necessary, in consequence of the new system of building and repairing ships, by what is called *Task* and *Job*; the former being applied to the building of new ships, and the latter to the repairing of old ones; both, in fact, mean, the paying for work by the piece, but estimated in a different way. Thus, for building a ship of 100 guns, and 2164 tons, by task, the sum to be allowed was calculated at L. 6615, or at the rate of L. 3, 1s. *per* ton; while for a 74 gun-ship of 1620 tons, the allowance was to be L. 4374, being at the rate of L. 2, 14s. *per* ton. But as it could not be expected that the workmen would require no payment till this ship was completed, or that they should be paid before-hand, it was necessary to ascertain the progress of the work, in order to pay them a proportionate sum; and, for this purpose, measurers were appointed, who had no interest in the work, to ascertain the value of the part performed. Job-work was attended with greater difficulty. The best estimate of the probable expence of repairing a ship is but a mere guess, as the extent of her defects are not known till every part has been examined. The usual mode was, to measure the works as they proceeded, by the quarter-men, checked by the foreman of the shipwrights,—approved by the assistant, who superintended the repair of the ship,—sent to the master shipwright, who, with the prices annexed, forwarded it to the Navy Board.

Abuses of the old System of Job-Work. The Commissioners of Naval Inquiry (*Sixth Report*) clearly expose the "combination of self-interest which has been permitted to exist against the public, in all the persons who were concerned in the accounts of job-work, and the fictitious manner of making up those accounts." The quarter-men, for instance, were paid wages according to the amount of the earnings of the men under their own superintendence, and the accounts of those earnings were taken by themselves. General Bentham has furnished an instance of the gross abuses which existed under the old system of job-work. "By the regulations of the Navy Board, nothing less than L. 5, 2s. was to be paid for the *smallest* repair of a 34 feet launch. If the above sum should be found inadequate to the payments for the work done to a boat of this class, the repair was then to be denominated a *middling* repair; in which case L. 11, 1s. was the exact sum. Again, if this sum were insufficient, the repair was to be denominated a *large repair;* and, in this case, although the value of the workmanship might have exceeded the sum of L. 11, 1s. only by a few shillings, the expence was to have appeared in the accounts as doubled, and set down L. 22, 2s., and nothing less was to be the exact sum paid for this work." Nothing was more common in estimating a man's wages, to find him working three or four tides, and very often three nights, in one day. (Bentham's *Services*, &c.)

Advantages of the new System. The whole of this system is now done away. The master-measurer being a professional man, has under his directions a certain number of sub-measurers, selected from among the shipwrights of the best characters for integrity and intelligence. These persons are to measure, daily, the work that has been performed in the course of that day by the several gangs of shipwrights, and value it according to a table which, after long experience and accurate observation, has been constructed by the officers and assistants of the yard, in such a manner that every piece of work performed on a new ship, from the keel upwards, and every bolt drawn or driven in the repair of an old one, has its adequate value; and, in order that task and job work should not any longer be, what the Commissioners of Naval Inquiry pronounced it to be, "the source of abuse and fraud," the quartermen do not, as formerly, partake of the earnings of the gang which they superintend, but are now sworn salary officers, whose interest it is, for their own character, and chance of advancement in the service, to see that every part of the work is performed in a proper and workmanlike manner; and the consequence is, that no new work is now paid for that is not actually performed; and that every part of the work is performed in the best possible man-

ner. By these schemes, it appears that a shipwright could earn generally about 6s. a-day in summer, and 4s. 6d. a-day in winter. The system of measurers, sub-measurers, quartermen, &c. being made salary officers, appears to be attended with very considerable expence; but the whole is a mere trifle, provided it be the means of preventing fraud, and of securing good ships to the navy. (See SHIP-BUILDING.) That it does both appears to be the opinion of the best informed officers of the dock-yards; and the advantages which are so obviously to be derived from piece-work, provided the workmen are properly superintended, have induced the Navy Board to extend the task and job scheme not only to all the artificers of the dock-yards, but also to the labourers, where it can be done, as is now the general practice in almost all private manufactories. (*Third Report of Commissioners of Naval Revision.*)

Master Mast-Maker.

Master Mast-Maker, &c.—These masters of the several trades have the immediate superintendence of all the work done, and the persons employed in their respective departments; the mast-maker, boat-builder, joiner, house-carpenter, bricklayer, smith, and painter, being under the direction of the master shipwright, and his assistants; the sail-maker and rigger under the master attendant, and the rope-maker under that of the clerk of the rope-yard. Each of these masters have immediately under them a certain number of foremen, who superintend the working men, and take a particular account of the earnings of each. Both masters and foremen are taken from among the most respectable and intelligent of the several trades, and are a most useful body of men in the dock-yards.

Cabin-Keepers.

Cabin-Keepers.—The store-cabins in the dock-yard contain an assortment of stores for the current service, and are placed under the charge of the master shipwright or the master-attendant, according to the nature of the stores which are placed in them. To each of these inferior store rooms is appointed a cabin-keeper, who is charged by the store-keeper with the quantities of the several articles delivered to him, an account of which is entered in his supply-book; and the articles delivered by him on a note from the superior officers of the yard, are entered in his expence-book; and once a-week these books are compared by the superior officer of the department under which the cabin is placed, to see that no waste or embezzlement may have taken place. The cabin-keeper being an officer of trust, is required to give bond, with a respectable security, in the sum of L.200, for the due and faithful execution of his office.

Surgeon and Assistant.

Surgeon and Assistant—Have the care of the men belonging to the Ordinary in all cases of sickness or hurts; but of the workmen in the dock-yards, in cases of wounds or hurts only. One or other are required to attend constantly during the working hours, and to muster such of his patients as are able to attend every morning. The surgeon is to examine every artificer, apprentice, and workman, of every description, previous to his entry on the yard, to ascertain his fitness as to bodily strength, and whether he may labour under any disease or infirmity. He is strictly forbidden to have any professional practice whatever but what may be required by his public duty, and his attendance on the families of the officers resident in the dock-yard.

Boatswain.

Boatswain—Has the superintendence, under the master shipwright, and his assistant, of all the scavelmen, labourers, and teams of horses; of the unloading and landing of all timber and other stores; of all the cranes, crane-ropes, slings, &c. and of the fire-engines; and he keeps a daily account of the employment of the scavelmen, labourers, and teams, a copy of which is delivered at the end of every week to the master shipwright.

Warden.

Warden of the Gate—Has the superintendence of all wardens employed in the yard, and has charge of the gate, through which he is not to permit any stranger, improper person, or foreigner, to pass. He is to see that nothing is carried out of the yard improperly, and to cause the bell to be rung at the proper hour, for the workmen to enter, according to the season of the year.

Established Officers of the Victualling-Yard.

The principal officers at each of the victualling establishments at home are, 1. The agent victualler. 2. The clerk of the check. 3. The store-keeper. After these come, 1. The master cooper. 2. The master brewer. 3. The master butcher. 4. The master baker. 5. The miller; and 6. The superintendent of the wharf. The agent has L. 600 a year; the rest from L. 400 to L. 200 a-year, and the number of all the salary officers, including the clerks, may amount to about 40 at each of the four victualling establishments at home.

Superannuations.

All the officers, clerks, artificers, and labourers of the civil establishments of the navy, are entitled to a pension on their retirement on account of old age or infirmities, proportioned to the length of their services, provided each service shall have exceeded ten years.

The total annual expence of all the branches of the civil establishments of the navy in the year 1817 stood as under:

Admiralty-office, with all contingencies,						L. 53,763	16	7
Navy pay-office,	do	- -				43,241	15	4
Navy-office,	do	- -				77,504	18	6
Deptford dock-yard,	do		L. 27,582	0	0			
Woolwich	do	do	32,440	12	0			
Chatham	do	do	36,883	10	4			
Sheerness	do	do	26,659	6	0			
Portsmouth	do	do	59,969	5	0	381,403	19	4
Plymouth	do	do	45,299	13	0			
Outports	do	do	9,687	13	5			
Foreign yards,		do	42,599	18	7			
Victualling-office,		do	45,541	13	4			
Victualling-yards,		do	54,740	7	0			
Superannuations of the officers, secretaries, clerks, artificers, and labourers retired from all the establishments of the civil concern of the navy,						85,870	1	8
Total annual expence, - -						L. 641,784	11	5

(*Estimates of the Navy for* 1817.)

Dollond.

DOLLOND (John), a practical and theoretical optician of the highest celebrity; the discoverer of the laws of dispersion of light, and inventor of the achromatic telescope; descended from a family of French refugees, was born in London 10th June 1706.

His first destination was the manufacture that afforded employment to the greater part of the French colony established in Spitalfields; and he passed some of his earlier years in the mechanical labour of a silk weaver. He was, however, always attached to the mathematics and to natural philosophy; and he even extended his studies to the outlines of anatomy and of scholastic divinity: and in the pursuit of these objects he found himself obliged to acquire a competent knowledge of the Latin and Greek languages: a task which was much facilitated to him by the possession of a memory no less retentive, than his observation was accurate, and his reasoning correct. He married early; and he continued in his first occupation till he had established his eldest son, Peter Dollond, who inherited his own tastes, as an optical instrument maker; and the success of the undertaking was such, as to induce him, in 1752, to leave his own business, and to enter into partnership with his son in Vine Court.

These arrangements having taken place, it was not long before Mr Dollond communicated to the Royal Society some of the results of the application of his inventive powers to his new pursuits: and Mr Short, who then enjoyed the highest reputation as an optician, paid him the compliment of bringing them forward to the Society under the auspices of his name.

1. *A Letter to Mr James Short, F.R.S. Concerning an Improvement of Refracting Telescopes. Phil. Trans.* 1753. p. 103. The author here describes a telescope with six glasses, as calculated for correcting, either wholly or in great measure, the errors of refraction arising from the dispersion of the different colours, as well as from the spherical form of the surfaces of the eye-glasses: appealing to the superiority of the telescopes, which he had thus constructed, above those which had before been in use: but he reserves a more ample detail of the theory for a future occasion; which, however, does not appear to have presented itself, the improvement having been superseded by others incomparably more important.

2. *A Letter to James Short, A.M F.R.S. Concerning a mistake in Mr Euler's Theorem for correcting the Aberration in the Object Glasses of Refracting Telescopes*; read 23d November 1752; together with an introductory letter of Mr Short, in which Euler's calculations are somewhat too categorically condemned, and with Euler's answers to Short and Dollond. *Phil. Trans.* 1753. p. 287. It is remarkable, with what profound respect the experiments of Newton are treated in Mr Dollond's letter: "It is somewhat strange," he says, "that any body now-a-days should attempt to do that which so long ago has been demonstrated impossible:" but although the investigation of truth was perhaps in this instance retarded, yet its ultimate discovery was not prevented by a just deference to a high authority. Euler was, however, certainly right in considering the law which he had assumed as sufficiently compatible with the results of Newton's experiments; although he was much mistaken in his conjectures respecting the achromatic properties of the eye.

3. *A Description of a Contrivance for Measuring Small Angles. Phil. Trans.* 1753. p. 178. This apparatus consists of a divided object-glass, with a scale for determining the distance of the images, by measuring the linear displacement of the two portions of the glass; which subtends the same angle from the focus of parallel rays, as the actual distance of the images does from the object-glass. The apparatus is recommended as particularly calculated to be applied to a reflecting telescope, and was afterwards adapted by Mr Peter Dollond to the improved achromatic telescopes. Mr Savery and Mr Bouguer had before used two separate lenses in a manner nearly similar; but the employment of a single glass divided affords a much more convenient arrangement.

4. *An Explanation of an Instrument for Measuring Small Angles. Phil. Trans.* 1754. p. 551. This paper contains a more detailed theory of the divided object-glass micrometer, and a testimony of its utility from Mr Short, founded on actual experiments.

5. *An Account of some Experiments concerning the Different Refrangibility of Light. Phil. Trans.* 1758. p. 733. We have here the important results of a series of accurate experiments, by which the author had undertaken to investigate the foundations of the Newtonian theory of refraction; though he began them without any hope of a success so brilliant as that which ultimately crowned his labours.

It was in the beginning of 1757 that Mr Dollond made the decisive experiment of putting a common prism of glass into a prismatic vessel of water, and varying the angle of the vessel till the mean refraction of the glass was compensated; when he found that the colours were by no means destroyed, as they were supposed to have been in a similar experiment related by Newton; for the remaining dispersion was nearly as great as that of a prism of glass of half the refracting angle. Mr Dollond then employed a thinner wedge of glass, and found that the image was colourless when the refraction of the water was about one-fourth greater than that of the glass. He next attempted to make compound object-glasses by inclosing water between two lenses; but in this arrangement he found great inconvenience from the spherical aberration. So that he was obliged to try the effects of different kinds of glass, and he fortunately discovered that the refractions of flint and crown glass were extremely convenient for his purpose, the image afforded by them being colourless, when the angles were to each other nearly as 2 to 3; and hence he inferred that a convex lens of crown glass, and a convex one of flint, would produce a colourless image when their focal distances were in the same proportion. The spherical aberration, where the curvature was so considerable, still produced some inconvenience; but having four surfaces capable of variation, he was enabled to make the aberrations of the two lenses equal; and since

they were in opposite directions, they thus corrected each other. All these arrangements required great accuracy of execution for their complete success; but, in the hands of the inventor, they produced the most admirable instruments; and he was singularly fortunate in obtaining a quantity of glass of more uniform density than has been since manufactured on so large a scale. He afterwards made some small Galilean telescopes with triple object-glasses, and Mr Peter Dollond applied this construction to the longer telescopes, with compound eye pieces, the alteration rendering the spherical aberration still more manageable.

The merits of Mr Dollond's inventions were promptly acknowledged on the part of the Royal Society, by the adjudication of the Copleian medal for the year. In 1761, he was appointed Optician to the King, and was elected a Fellow of the Royal Society; a distinction which is often obtained on easy terms, by those whose situation in life exempts them from the suspicion of seeking it for any purpose degrading to science; but which is generally an object of considerable ambition to persons of mechanical or commercial occupations.

A considerable share of the credit due to Mr Dollond's discoveries has been very erroneously attributed, by some late historians and biographers on the continent, to Leonard Euler, a mathematician who, most assuredly, has little need of the appropriation of the merits of others to establish his claim to immortality. But in fact the only idea of Euler, that could be said to have furnished any hint to Mr Dollond, has been shown by the calculations of Dr Maskelyne, and by the experiments of Dr Thomas Young, and Dr Wollaston, to have been completely erroneous; nor did Euler even admit the accuracy of Mr Dollond's conclusions, after his discovery was made, without considerable hesitation and scepticism. Mr Klingenstierna had simply expressed a doubt with respect to the result of Newton's experiments, though he by no means suspected the extent of the error. Mr Peter Dollond has sufficiently vindicated his father's claim to complete originality, in a paper read to the Royal Society in 1789; he has also suggested an explanation of the origin of Newton's mistake, by stating that there exists a kind of Venetian glass, of which the dispersive power little exceeds that of water, while its specific gravity nearly approaches to 2.58, which is assigned by Newton to glass in general; and it certainly seems more probable that some such circumstance as this was the cause of the error, than that Newton should, as some have suspected, have mixed acetate of lead with the water which he used, for an experiment which was so much more likely to be satisfactory without it.

Mr Dollond's appearance was somewhat stern, and his language was impressive, but his manners were cheerful and affable. He was in the habit of attending regularly, with his family, the service of the French Protestant church. He constantly sought his chief amusement in objects connected with the study of those sciences which he had so much contributed to improve. Perhaps, indeed, he pursued them with an application somewhat too intense; for on the 30th of November, as he was reading a new work of Clairaut on the theory of the moon, which had occupied his whole attention for several hours, he had an attack of apoplexy, which shortly became fatal. He left two sons and three daughters. His sons succeeded to his business; and the younger dying a few years after, his place was filled by a nephew, who assumed the family name, and who still conducts the establishment with undiminished respectability and success. (Kelly's *Life of John Dollond, with an Appendix of all the Papers referred to*, 3d edit. 4to. Lond. 1808.) (A. M.)

DOLOMIEU (DEODATUS GUY SILVANUS TANCRED DE GRATET DE), a distinguished mineralogist and geologist; son of Francis de Gratet de Dolomieu, and Frances de Berenger, was born the 24th of June 1750, in the province of Dauphiné.

He was admitted a member of the order of Malta during his earliest infancy, as if he had been devoted from his cradle to glory and to misfortune. At eighteen he embarked in one of the galleys belonging to the order, and soon after unhappily found himself under the necessity of fighting a duel, in which his adversary fell. The laws condemned him to die; but he received a pardon from the grand-master; it was, however, necessary that it should be approved by the Pope, who for a long time refused to confirm it, notwithstanding the solicitations of several European powers in behalf of the offender; until his consent was at last obtained by the cardinal Torregiani. Dolomieu, in the mean time, was closely imprisoned in the island for nine months, and this period of solitude seems to have contributed materially to increase the seriousness of his character, and to confirm him in a contemplative turn of mind.

At the age of twenty-two he went to Metz, as an officer in the regiment of carabiniers, in which he had held a commission for seven years; and he displayed great courage and personal activity on occasion of an accidental conflagration, which occurred soon after. His leisure hours were employed in the study of chemistry and natural history, with the assistance of Mr Thirion, an apothecary residing in this city. He also became intimate about the same time with De la Rochefoucault, with whom he maintained an unshaken friendship ever after.

1. He commenced his literary career with an *Italian translation of* Bergman's *Work on Volcanic Substances*, to which he added some *notes*, and some observations on the *classification* of those substances.

2. He also furnished some *notes* to a translation of Cronstedt's Mineralogy.

3. In 1775 he published *Researches on the Weight of Bodies* at different distances from the earth's centre; and upon the recommendation of La Rochefoucault, was made a correspondent of the Academy of Sciences at Paris. This compliment seems to have contributed to his determination to relinquish his prospects of success in the army, and to devote himself exclusively to science. Having resigned his commission, he commenced his geological labours with a tour in Sicily, Italy, and Switzerland.

4. This expedition afforded him the materials for his *Voyage aux Iles de Lipari, fait en* 1781, which he

Dolomieu. published in 1783, with some other tracts. He describes a singular kind of volcano at Macaluba in Sicily, formed by air bubbling up from the crater, and causing its contents to overflow. The Essay on the Climate of Malta is rendered inconclusive, by the imperfection of the eudiometrical apparatus, that was then commonly employed.

5. He spent a part of the same year in examining the effects of the earthquake in Calabria, which are described in his *Mémoire sur les tremblemens de terre de la Calabrie.* 8vo. Rome, 1784. Among other observations he notices the singular fact, that all those parts of Calabria, to which the earthquake extended, are of a calcareous nature, without any traces of volcanic substances.

6. He published in the *Journal de Physique*, Vol. XXV. p. 191, a paper *on the extinct volcanos* of the Val di Noto in Sicily.

7. His *Mémoire sur les Iles Ponces*, 8. 1788, contains also a catalogue of the productions of Mount Etna, and an account of the eruption of 1787.

At the beginning of the revolution, Dolomieu embarked, together with his friend La Rochefoucault, in that which appeared to be the cause of liberty. He was in Paris on the 14th of July, but he did not accept of any office under the newly modified government. La Rochefoucault soon fell a victim to the horrors of the times. Dolomieu was present in his last moments, and received the affectionate messages which he sent to his mother and his wife, who were more distant witnesses of the dreadful scene.

8. No longer hoping for any benefit to his country from the political events of the day, he appears to have resumed his gelogical studies in other parts of Europe. In a *Letter on the origin of basalt*, dated Rome, 1790, *Journ. Phys.* Vol. XXXVII. p. 193, he considers some stones of this description, for instance, the black trapps of Saxony, as the productions of water; and others, particularly the varieties found in the south of Europe, as of volcanic origin.

9. He writes, in 1791, a *Letter from Malta*, describing a species of limestone, found in the Tyrol, hard enough to become phosphorescent upon collision, and not effervescing with acids until powdered. It was afterwards called the Dolomite. *Journ. Phys.* Vol. XXXIX. p. 3.

10. In a paper of *Directions for Naturalists*, he gives some useful advice to the circumnavigators about to sail to the South Seas. *Journ. Phys.* Vol. XXXIX. p. 310.

11. A series of his essays *On Compound Stones and Rocks* appeared from time to time in the *Journal de Physique*, Vol. XXXIX. p. 374; Vol. XL. p. 41, 203, 372. In these he insists on the necessity of supposing that the ocean must have acted with great violence, in reducing the continents into their present state; neither the slow subsidence of a general deluge, nor the continued action of ordinary rivers, being sufficient to explain the phenomena; and he remarks, that a violent agitation, such as must necessarily be supposed to have taken place, would naturally cause several alternations in the state of the waters. like immense waves or tides, which must have contributed to the modifications impressed on the earth's form. Indeed, the facts which suppor this opinion appear to be so obvious and so numerous, that it is difficult to understand how the opposite hypothesis could ever have become popular. Dolomieu.

12. In the same volume there is a short paper *On Petroleum found in Rock-Crystal*, and on some elastic fluids obtained from it, p. 318.

13. The progress of his memoirs was now interrupted by the proscription, in which many of the best and wisest of his countrymen were indiscriminately involved. "His duty and his inclination," he says, in a *Note* without a date, "required the devotion of his time and his arm to the defence of his king;" and he was obliged to submit to a temporary dereliction of his pursuits of science. P. 481.

14. But the cause was hopeless; and it was impossible for him to render it any essential service. He soon resumed his pen, and took occasion to express, with great spirit and energy, his political feelings, in his *Memoir on the Physical Constitution of Egypt. Journ. Phys.* Vol. XLII. p. 41, 108, 194. In Egypt, he observes, there are many calcareous rocks and sands, which cannot have been brought down by the Nile; but there is also much of the soil which has the appearance of having been derived from the mud, with an admixture of sand only. The same cause, he thinks, may possibly have raised the bed of the river, so that the relative height of the inundations may have been little altered. He conceives that the Delta has increased even in modern times, though far less rapidly than it appears to have done formerly; for he is disposed to admit the credibility of the Homeric account of the distance of the Pharos from the continent, although he attempts to explain a part of the supposed change, by the filling up of the lake Mareotis only; and, on the whole, he imagines that about 1000 square leagues of the surface of Egypt have been gained from the sea. He has not, however, thought it necessary to discuss the arguments, which Bruce and others have brought against the established opinion, and against the facts asserted by Herodotus in its support; although some of the best informed of modern travellers have allowed the accuracy of Bruce's statements relating to this subject.

15. In a short paper *On the Figured Stones of Florence*, Mr Dolomieu attributes the appearance of the arborescent and architectural figures, which characterize them, to the process of slow decomposition and oxydation, gradually producing the stains in the extremely minute fissures, which favour these changes. *Journ. Phys.* Vol. XLIII. p. 285.

16. Upon the establishment of the school of Mines, in 1795, he accepted the situations of Professor of Geology and Inspector of Mines. He was also made one of the original members of the National Institute of Sciences and Arts, then organized by a law of the existing government. From this time he appears to have redoubled the energy with which he had before laboured in the pursuit of natural knowledge, and he published a great number of memoirs in the course of a very few years. One of the first of these consisted of *Observations on a pretended Coal Mine, called the Désirée. Journal des Mines*, Year III. N. ix. p. 45.

17. His *Methodical Distribution of Volcanic Substances* appeared in the new *Journal de Physique*,

Dolomieu. Vol. (I.) XLIII. p. 102, 175, 241, 406; Vol. (II.) XLIV. p. 81. Of the five classes, which he had before proposed in his notes on Bergman, the first comprehends substances actually produced by volcanos; the second, substances thrown out by them unaltered; the third, bodies altered by the volcanic vapours; the fourth, bodies altered in the moist way; and the last, substances illustrative of the history of volcanos only. The subsequent papers are partly continuations of the *Memoirs on Compound Rocks;* and they also relate particularly to the nature of lavas, some of which are shown to be formed from argillaceo-ferrugineous stones. The heat of lavas has been pretty accurately entertained, in some cases, by the fusion of silver coins exposed to it, while those of copper remained entire; there is, however, an account of a stream of lava over which some nuns are stated to have walked while it was yet fluid; and this circumstance Mr Dolomieu attributes to a mixture of sulphur, which remained melted at a temperature comparatively low. Some objections to this opinion have, however, been advanced by Mr Sage. *Journ. Phys.* Vol. XLV. p. 281. *An Explanation of the New Method adopted in the Description of Minerals,* was also published in the *Magazin Encyclopédique,* Vol. I. p. 35.

18. Among the shorter essays of Mr Dolomieu, we find a *Description of the Beryl. Journ. des Mines,* year IV. Ventose, p. 11.—19. *Description of the Mine of Manganese at Romanecche.* Germinal, p. 27. —20. *Letter on the Heat of Lavas.* Messidor, p. 53. —21. *On Quartzose Concretions,* p. 56.—22. *On Ancient Lithology. Mag. Enc.* I. p. 437.—23. *Description of the Emerald,* II. p. 17, 145.—24. *A Letter from Berlin on the Magnetic Serpentine,* II. Vol. VI. p. 7.—25. *On the Leucite, or White Garnet. Journ. des Mines,* year V. p. 177.—26. *On the Necessity of Chemical Knowledge to a Mineralogist; and on the term Chrysolith,* p. 365.

27. *An Introductory Discourse on the Study of Geology* appears in the *Journal de Physique,* Vol. XLV. p. 256. It was preliminary to a course of lectures on the natural position of minerals; and it contains good and detailed directions for the use of students, with some eloquent advice on the benefits of travelling, and on the merits of temperance and simplicity of manners.

28. In the next volume, p. 203, our author announces the *Discovery of the Crystallized Sulphate of Strontia in Sicily.* It had before been found uncrystallized in France.

29. *On Colour as a Characteristic of Stones. Journ. Phys.* Vol. (III.) XLVI. p. 302. This essay contains some objections to Werner's habit of relying too implicitly on colour; and the white tourmaline of St Gothard is adduced as an instance of the triumph of form over complexion: a just tribute of commendation is also paid to the merits of Haüy.

30. A paper *On the Pyroxene, or Volcanic schörl,* is chiefly destined to support the opinion that such crystals have been formed previously to the existence of the volcano, by the observation of a specimen found adhering to a rock which had never undergone the effect of fire. *Journ. Phys.* Vol. XLVI. p. 306.

31. *A Memoir read to the Institute* contains the report of Mr Dolomieu's mineralogical tours, made in the years 1797 and 1798. *Journ. Phys.* Vol. XLVI. p. 401. *Journ. des Mines,* year VI. p. 385. He visited the south of France, the Alps, and the neighbouring lakes and mountains, almost always on foot, and with his hammer in his hand, accompanied by Brochart, Cordier, Bonniers, and his brother-in-law, the Marquis de Drée. From his observations in Auvergne, in particular, he concludes that the foundation or origin of the volcanoes there is certainly below the granite rocks, which therefore cannot, properly speaking, be called primitive; and he proceeds to a much bolder and less admissible conjecture, that the central parts of the globe are at present in a state approaching to fluidity, which he attempts to support by the ready transmission of the shocks of earthquakes to distant places; and he even quotes the authority of Lagrange as having been disposed to encourage the opinion. Volcanos, in general, he divides into ancient and modern, as separated by the intervention of the changes which have reduced the continents to their present form. With respect to the heat of the lava, he observes, that it has not been sufficient to expel the carbonic acid from the limestone which has been exposed to it. He also remarks, that, where basalt in fusion has been suddenly cooled by water, the contraction has caused it to divide into columns, which are not crystalline, because their angles are irregular, and which are smaller and more uniform in proportion as the water is deeper. He contrasts the horizontal strata of France with the vertical tables of the Alps; and particularly describes the accretion of a mantle of calcareous substances, two miles in height, which has attached itself to the north-east faces of the Alps, subsequently to their first formation as mountains. From this expedition he brought home an immense collection of rocks and stones, principally valuable for their arrangement with a view to the illustration of his particular doctrines in geology; which, with the rest of his cabinet, have since formed a part of the superb museum of Mr de Drée.

32. He published, about the same time, a paper *On the Mountains of the Vosges. Journ. des Mines,* year VI. p. 315.

33. *Extract of a Report on the Mines of the department of the Lozère,* p. 577.

34. The only communication of Mr Dolomieu, printed in the *Memoirs of the Institute,* is rather on a mechanical than a mineralogical subject, containing an *Account of the Art of Making Gun-Flints. M. Math.* Vol. III. p. 348. Nicholson's *Journal,* 8. Vol. I. p. 88.

He was engaged, after his return from Swisserland, in some mineralogical contributions to the *Encyclopédie Méthodique;* when he was invited to take a part in the scientific arrangements of the expedition to Egypt. He did not, however, strictly confine himself to this department; but was successfully employed as a negociator for the surrender of Malta. In Egypt he visited the pyramids, and examined some of the mountains which form the limits of the country; but his health soon compelled him to return to Europe. In this voyage, the vessel on board of which he had embarked was nearly overwhelmed by a tempest, and appears to have been only saved by the

Dolomieu.

temporary expedient of throwing overboard pounded biscuit mixed with straw, which entered the leaks with the water, and afforded a partial remedy, which was repeated from time to time, until the vessel, at the last extremity, was driven into a port in the Gulf of Tarentum. The counter-revolution of Calabria had occurred but a few days before; and Dolomieu, with his companion Cordier, and many others of his countrymen, were thrown into prison; and they even owed their lives to the great exertions of an individual among the insurgents in their favour. They were afterwards removed to Sicily, but with the loss of their collections and their manuscripts; and Dolomieu, being denounced, as a member of the order of Malta, for high treason, was separated from his countrymen, and closely confined in a dungeon. Solicitations were addressed to the King of Naples, on his behalf, by the National Institute, by the French government, by the King of Spain, and in the name of the Royal Society of London, although its illustrious President was certainly not "at the time in Sicily," as the *Nouveau Dictionnaire Historique* affirms; but the captive derived essential assistance from the good offices of an English gentleman at Messina, and some Danes accommodated him in his pecuniary arrangements. While still a prisoner, he was appointed successor to Daubenton, at the Museum of Natural History; and the very circumstance of his captivity seemed to give him an advantage over his competitor. In the treaty made by the French with the King of Naples, after the battle of Marengo, it was expressly stipulated, that Dolomieu should be set at liberty.

35. Upon his return to Paris, he was made a member of the Conservative Senate, and he delivered, soon after, a course of lectures on the philosophy of mineralogy. He had written part of an essay on this subject during his imprisonment in Sicily, with a bone for a pen, and a mixture of soot and water instead of ink, on the margins of such books as were allowed him; and his last publication was *Sur la Philosophie Minéralogique, et sur l'espèce Minéralogique.* Paris, 1801. His classification depended on considering the species as determined by the integrant molecule, and on arranging the different external forms as varieties, whether regular, as modifications, or irregular, as imperfections; besides the variations of colour and appearance, and the more essential affections of the consistence of the substance, which may be called contaminations; but the whole essay may be considered as rather of a logical than of a physical nature.

After the delivery of his lectures, he set out upon a new expedition to his favourite mountains, in company with Mr Neergard and Mr d'Eymar, who published an account of the journey. 8. Par. 1802. He meditated a tour into Germany and to the North of Europe, but his return to Paris was interrupted by indisposition, when he had arrived, by way of Lyons at Chateauneuf, where he met his sister and his brother-in-law; and this journey was his last.

The merits of Dolomieu consisted as much in his personal character, as in his scientific attainments. His conversation was modest, though his courage was heroic; his manners were simple though refined; and though his talents were considerable, they seem to have been surpassed by his industry. It has been remarked, that he often undertook more than he had any reasonable prospect of completing; but, in the meantime, he was perhaps as happy in the pursuit, as he would have been in the attainment of his object. He died, universally regretted, at Drée, near Maçon, the 27th of November 1801, in the midst of his affectionate family, who had been the partakers in his pursuits, and the consolations of his misfortunes.

Dolomieu || St Domingo.

Lacépéde Notice Historique sur le vie et les ouvrages de Dolomieu. Mém. Math. Inst. Vol. VII. 1806, p. 117. *Chalmers's Biographical Dictionary*, Vol. XI. 8vo. London, 1813. (E. X.)

DOMINGO, St. Some account will be found of this large and fertile island in the *Encyclopædia*, under the article HISPANIOLA, and we shall now add such farther information respecting its climate, natural productions, and recent history, as is contained in later publications on the subject.

This island is, as described in the *Encyclopædia*, the largest of the Antilles, or Carribee Islands, extending from 17° 37 to 20 north latitude, and from 67° 35 to 74° 15 west longitude. It was called *Haiti*, or the Highland country, by the natives, from the mountains with which it abounded, more especially in the northern part. When it was first discovered by Columbus, it received the name of Isabella, in honour of the Queen of Spain, but its most common appellation is St Domingo, from its chief city. The country was formerly divided between the Spaniards, who were the original occupiers, and the French. These last, however, having been expelled by the black population, the division of the island which they formerly occupied is now known under the name of the kingdom of Hayti. The line of demarcation which separates those two divisions commences on the south side from the river Pedernales, or Flint river, and extends in a waving direction to the river Massacre on the north side. The country to the west of this line belonged to the French part, while that on the east side formed the Spanish part of the island. By far the greatest portion of the country was in the possession of the Spaniards; their division being reckoned to be 220 miles in length by 120 in breadth, of which, though a considerable part consists of mountains, these are said to be little inferior in fertility to the champaign country, and to be equally capable of cultivation. The Hayti division is of an extremely irregular figure. The land is deeply penetrated by the Gulf of Gonave, and is in some parts 170 miles in length, while, in others, it is not 30. It is nearly of the same breadth as the Spanish division.

General Description of the coast.

Great part of the coast of this island is rocky and dangerous, affording but an imperfect shelter to vessels overtaken by storms. Many of the shipping places on the southern shore are nothing more than open bays, which lie exposed to the storms and hurricanes of the autumnal months. The harbour of St Domingo, formerly thought so commodious and secure, has become too shallow to admit vessels of large burden. There are, however, besides roads and several small harbours, the bays of Neyba and

St Domingo.

Acoa on this coast. Into the first flows the river Neyba, which receives vessels of thirty tons burden; its stream, before entering the ocean, divides itself into various channels, which, annually changing, confound the pilot, and render the navigation difficult. These, if they were collected into one, would afford a deeper and safer channel. Ocoa Bay is a large convenient watering-place, with several small rivers falling into it. The entrance is two leagues across, and it gradually widens to near six. On the east side of this bay is the safe and capacious port of Caldera. On the south-east coast is the great Bay of Samana, which, in point of size and situation, is one of the most important on the island. From Cape Rafael, which forms the southern point of entrance into the Bay of Samana, to the opposite side of the island or peninsula of Samana, the distance is eighteen miles, which is closed in by a bulwark of rocks and sands, the entrance only being left clear, with a safe and deep channel between the shore of Samana and several detached islands. This bay is about sixty miles deep, and is surrounded on every side by a fertile country, suited to all the purposes of trade. Within the compass of this bay, whole fleets might ride at anchor in perfect security. The river Yuna, after being joined by the Cambu, and meandering through the rich plains of La Vega Real, falls into the bay of Samana, after a course of nearly one hundred miles. Bahia Ecossaise, or Scots bay, which is on the north side of the peninsula of Samana, is a dangerous rocky place. From thence to Puerto Plata, the coast extends about sixty miles in a north-west direction, and in this space stands Balsama bay, which has only fourteen feet depth of water, and is of difficult navigation. The harbour of Puerto Plata was first discovered by Columbus; the entrance is narrow but safe, and the neighbourhood is rich in every species of woods. There are several other small harbours and bays on this side of the island; but the coast is in general rocky and dangerous.

Soil and Surface.

A country of such magnitude as St Domingo, containing mountains of great height, with vallies of corresponding extent, necessarily comprises great variety of soil. In general, however, it is fertile in the highest degree, every where watered by copious streams, and yielding in abundance every species of vegetable produce which can minister either to the luxury or comfort of man. The soil consists principally of a rich clay, sometimes mixed with gravel, lying on a substratum of rock. That part of the island formerly occupied by the French is mountainous, but fertile and well wooded, and containing mines both of silver and iron. The Spanish part of the island is mountainous in many parts; while in other parts, the country is spread out into extensive plains. These are generally in a state of nature, covered with herbage or with woods of immense growth and the most luxuriant foliage. The mountains intersect the island in two principal chains from east to west. From these, secondary and partial ridges diverge irregularly in different directions, forming beautiful and fertile vallies watered by numerous streams. The highest mountains of the interior, particularly those of Cibao, rise to the height of 6000 feet above the level of the sea. To the north of the capital is the valley called Vega Real, or Royal Field, which is by far the largest and finest in the island. Westward, it extends to the old French line of demarcation, and in this part it is watered by the river Yaque; to the east, where it is watered by the river Yuna for the space of fifty miles, it projects to the head of the bay of Sumana, and is watered by numerous smaller streams, which cross it in various directions. This valley may be said to extend in length about eighty leagues, and in breadth from ten to fifteen.

Edwards, in his *Account of the West Indies*, is of opinion, that this and several other districts would, under proper management, yield a greater return of sugar and other valuable commodities than all the British colonies in the West Indies. Other plains also of less extent, but of equal fertility and of easy access, are every where found interspersed among the mountainous tracts. Westward from St Domingo, along the southern coast, is the valley of the river Banis, extending from Nisao to Ocoa. Here the pasture is good; but the country is not so well watered as in the other parts of the island; an inconvenience which is sensibly felt by the cattle during the dry months. In some cases this evil is remedied by the rivulets, which, descending from the mountains, intersect the low lands in various directions, and afford, in the event of drought, the never-failing resource of artificial irrigation. Even the aboriginal inhabitants availed themselves of this advantage for flooding their lands in the dry season, and some of the earlier Spanish settlers appear to have followed their example; as there are many spots now covered with thickets or weeds, on which there appear formerly to have been plantations both of sugar and indigo; and even in its wild and uncultivated state the ground in this tract produces in great luxuriance many valuable plants, such as the *cactus*, in several varieties, the indigo plant, and a species of cotton of which the wool is reddish, with various others; thus plainly indicating, that the hand of industry is only wanting to quicken into activity the latent fertility of the soil. Farther to the westward and to the north other vallies are found; but where the land, as in this island, is every where intersected by ranges of mountains, it is impossible, in any general sketch, particularly to describe that continual succession of hill and dale which diversifies the face of the country. Eastward from the capital are those immense plains called Los Llanos, which stretch out to a vast extent on a dead level. They are covered with herbage, and the eye wanders unobstructed over the wide expanse of waving grass, which is occasionally diversified by a natural clump of trees, that seem planted by the hand of man. These have generally sprung up on the margin of some spring or collection of water, round which they thrive as far as the moisture extends over the ground. Here scattered trees afford shelter to the ranging cattle from the mid-day heat. These plains occupy almost one-sixth part of the island, extending nearly to its eastern coast, to the distance of more than ninety miles by about thirty wide. They form an immense natural meadow, covered with pasture for vast herds of cattle, which belong to more than a hundred dif-

 ferent owners. These are annually collected, counted, and the young branded at the time when the calf cannot mistake its mother; and it is astonishing with what dexterity the herdsman, with a lance in his hand, contrives to separate one of his master's stock from the rest. In the dry season it is customary to burn all the grass on these extensive plains; and the eastern part of this tract, from which the wind regularly blows, being first kindled, the whole country is soon involved in one general conflagration. During this season the cattle generally take refuge in the forests, in search of the herbage which the sun has not had power to consume; and the burnt grass serving as an annual manure to the soil, a new crop springs up with fresh luxuriance after the parched earth is refreshed by the periodical rains.

Climate.

St Domingo is of a hot and moist climate; but the heat is mitigated by the regularity of the sea-breeze, and by the contiguity of the mountains. In the plains the thermometer rises to 96°, sometimes to 99°; but in the mountainous tracts it seldom rises above 78°. In the more elevated parts, a blanket is not unwelcome during the nights, and in the highest mountains a fire is frequently necessary. In those situations meat may be kept for several days, and in the morning hoar frost is frequent. The seasons, as in tropical countries, are divided into the wet and the dry. The rains are periodical, and are heaviest in May and June, when the rivers, which at other times can scarcely supply water for a continued stream, overflow their banks, and, with an impetuous torrent, sweep over the neighbouring plains. The climate of St Domingo is unhealthy to Europeans, owing to these violent heats and heavy rains; and hence all metals, however bright their original polish, soon contract a tarnished appearance. This is more observable on the sea coast, which is also more unhealthy than the interior parts of the island. Hurricanes are not frequent, but in the southern parts of the island violent gales of wind, generally preceded by a closeness and sultriness in the atmosphere, frequently occur. These, however, are not attended with such fatal effects as the hurricanes in the Windward Islands.

Rivers.

The island of St Domingo abounds in rivers and smaller streams, which flow from the mountains in the interior, in different directions to the sea. Of these the principal are the Haina, the Nigua, the Nizao, the Ozama, the Neyba, the Ocoa, the Yane, the St Yago, or the river of Monte Christi. The Haina takes its rise at the distance of three leagues from the city of St Domingo, and it falls into the bay of the same name, after flowing through a country which was once covered with plantations of cocoa, sugar, indigo, cotton, &c. but is now overgrown with wild shrubbery. The Nigua, about two leagues northward, rolls over a beautiful bed of sand and pebble, for a distance of nine leagues, in such a meandering course, that it is crossed five times within the compass of five miles. The banks of this river were formerly in a high state of cultivation, but now a muddy aqueduct, reservoir, or rent sugar boiler, seen at intervals through the trees, is all that remains to mark the former seat of European industry. Considerable quantities of wood are still floated down its stream, which in the dry season is very low, and, except when swelled by the rains, is easily fordable. The Ozama, after being joined by the river Isabella, besides a variety of smaller streams, runs past the city of St Domingo, of which it forms the port. Its shores are thickly covered with woods, and at its mouth it is as wide as the Thames at Chelsea. This stream is of great convenience to the capital, in facilitating the conveyance of provisions and produce from the interior. In the rainy season it overflows its banks, and for some miles tinges the sea with the muddy colour of its water. The Neyba, which empties itself into the bay of the same already described, takes its rise in the mountains, and runs in an unequal stream of about 100 miles, through a beautifully picturesque and woody country. It receives the waters of many inferior streams. The river Yane, or Yuna, which is joined by the Camu, meanders through the rich plains of La Vega Real. It is navigable during a great part of its course, which is stated by Walton to be 200 miles in length, and it receives forty other smaller rivers, that cross the country in different directions, and afford advantages for interior intercourse rarely to be found. The above mentioned rivers fall into the ocean on the south and east parts of the island. The river De Monte Christi, or St Yago, enters the sea on the north shore, in the bay of Mancenillo, after flowing from the inland town of Santiago through a long extent of plains and tobacco lands. Near the south part of the French line of demarcation is the beautiful lake De Henriquillo, which is about eighteen leagues in circumference, and though it is about eight leagues from the sea its water is perfectly salt, and of the same specific gravity as that of the ocean. The same fishes are also found in it, such as the shark, seal, porpoise, &c. and they are of similar size with those found in the ocean. In the centre is a small island, which is described as being a singularly romantic and beautiful spot, containing springs of fresh water, and abounding in wild goats and game.

Vegetable Productions.

The fertile soil of St Domingo is distinguished by the variety of its vegetable productions, many of which are exceedingly rare and valuable. The mahogany tree, the wood of which is at present the chief commodity exported, is found in great abundance. It is a tall straight and beautiful tree, hard, and of a close grain, when it grows on a barren soil, but paler, open grained, and more finely variegated on the low and damp lands. The manchineel tree affords a beautiful species of wood, richly veined like marble, with streaks of green and yellow, and susceptible of the finest polish; but in consequence of its containing a poisonous juice, of a white colour and of an acrid quality, the smallest particle of its dust falling into the eyes of the workmen when they are sawing it, occasions instant inflammation, and, frequently, total blindness. To avoid this danger, they have their eyes protected by a covering of gauze. Several species of dye-woods are produced in the forests; but none of them have been tried except fustic, which is a handsome tree with a small leaf. There is a tree called the Jagua, the fruit of which is accounted a delicacy by the natives; its juice is as clear as water, while it makes a stain on linen which

St Domingo. is indelible. Different kinds of lignum vitæ are found in the woods which line the coast. The most valuable is that which, when cut, is of a dark green colour, and grows in arid lands. The quiebra hacha or iron-wood, which is of a similar species, has the singular peculiarity of petrifying when stuck in the damp ground. There are two kinds of ebony, the green and the black, and several other woods with the same properties, which grow unnoticed, and without even a name, in those unexplored forests. The capa is well adapted for the sheathing of vessels, as it is impervious to the worms, which quickly consume most other woods. On the north side of the island there are extensive forests of pine, which is much used for the purposes of ship-building, but is excluded from domestic use, from its being the favourite lodging of the white ant, one of the most destructive insects in the West Indies. Brazil wood is common along the coast; but owing to the want of encouragement, it has never become an article of general trade. The satin wood, both of the white and yellow species, is abundant. It is heavier than that of the East Indies; has a more agreeable smell, and takes a finer polish. The cotton tree is the largest of all the vegetable productions, and out of its trunk are made the lightest and the most sizeable canoes. It affords a species of down which has been found well adapted for beds, and has also been tried with success in the making of hats. The sand box tree is of no commercial utility; but it is frequently used in hedges, and from its thick and gloomy shade is particularly well adapted for overhanging a road. Its fruit possesses the remarkable property of exploding with a noise resembling the discharge of a pistol, to the astonishment and alarm of the traveller who happens to be riding under the tree. Every variety of the palm tree is found in the woods, of which they form a principal ornament, and are besides useful for domestic purposes; the grains of some serving for the sustenance of birds or fattening of hogs, while the spreading leaves are employed in the thatching of houses, and in the manufacture of baskets or similar articles. The palmetto or mountain-cabbage is an erect and equal tree, which grows to the height of seventy feet, with the cabbage on the top. There is a dwarf tree of the same kind, the juice from the berries of which is reckoned a cure for low spirits. In the congenial soil of this fertile island the sugar cane, cotton and coffee plants, grow in the greatest luxuriance. There is also the calabash, the fruit of which serves as a substitute for earthen-ware,—the plantain, the staff of life in the West Indies—vanilla, which is found indigenous in the unfrequented woods—quassia, simarouba, which is a tall and stately plant, waving gracefully in the wind—sarsaparilla, indigo, tobacco, turmeric, ginger and rice plants. The fruits and nutritive roots of St Domingo are nearly the same as those of Jamaica; but they are more abundant, and extremely fine. Of these may be enumerated the choux caraib or Indian kale, with a variety of other vegetables that come under the same denomination, the avocato, or vegetable marrow, the melon, sapadillo, guava, pine-apple, bread and jack fruit, mango, nuts, rose-apple, plums, &c. of many different species. Flowers exist in endless variety and splendour, to adorn the wild scenery of the woods, and to exhale their fragrance in the desert air.

Mines. In addition to all its other valuable productions, this island formerly contained considerable mines of gold, silver, copper, and iron. But the mines of the two former metals have, according to that strange and perverted policy by which Spain has uniformly sought to depress her colonies, been long closed against the industry of the inhabitants, and a military force has been even posted at the different mining stations, to prevent those hidden gifts of nature from being brought to light, and converted into active and productive capital, for the improvement of commerce and the benefit of the world at large. Before these absurd prohibitions were enforced, St Domingo yielded a valuable produce of the precious metals. About eight miles from the capital were situated the mines of Buena Ventura, which frequently yielded large pieces of gold. In the centre of the island other mines are also situated, which were still more productive. The mines of Cibao were extremely rich, and near La Vega, at the source of the Yuna river, and Santiago at the source of the river De Monte Christi, large particles of gold are still washed down by the periodical rains. In the stream of the Yaque river, grains of gold are found, of which some beautiful specimens were seen by Mr Walton. (*Account of St Domingo.*) In the southern districts of the island are situated the mines of Guaba, Rubio, and Baoruco, where several adventurers are said to have enriched themselves by merely washing the gold from the sand with which it is intermixed. The Maroons, who occupy the hills in the latter place, which extend to the coast of the bay of Neyba, have no other way of procuring the clothing which they are in want of but in exchange for the gold which they extract. According to Herrera, as quoted by Mr Walton, the produce of these mines formerly amounted to 460,000 marcs of gold of eight oz. each, exclusive of what was manufactured and sent away in ornaments. On the road to La Vega, at a place called Garabacoa, is situated a rich silver mine, and another twelve leagues from Santiago, on the margin of two small rivulets. There is also a mine of this metal on the Yaque river; and near the capital, on the Haina river, is an excellent vein that has been worked. There are others in different parts of the island, and on the east coast is one that was formerly known to the Indians. There is a good iron mine about seven leagues from the city of St Domingo, and a finer one still near Cotuy, the produce of which might easily be transported to the bay of Samana by the river Yuna. Quicksilver is found at the source of the river Yaque; also near the gold mines of Cibao; and west from the Haina river there is a barren ridge abounding in this mineral. St Domingo also produces jasper, porphyry, agates, antimony, of which there is a mine yielding pieces of six and eight pounds, mineral copperas, red ochre in globules as large as a pigeon's egg, amethysts of a transparent violet colour, and of an excellent water, and in the Neyba and Hincha rivers, pebbles have been found containing brilliants.

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Animals.

The indigenous quadrupeds of this island were confined to four species, which the Indians called Hutia, Quemi, Mohuy, and Cory. Of these, all are extinct except the first. The hutia or agouti cat resembles the squirrel and rabbit; it is of a grey colour, but is not so dexterous as the squirrel in climbing trees, though, like this animal, its movements are assisted by its tail. Another of these four animals resembled a Guinea pig without hair, and a third a dog which did not bark, and which the Indians had contrived to domesticate. St Domingo, however, has procured, by its intercourse with Europe, a new stock of animals, of far more importance than the diminutive species which it has lost. These consist particularly of horned cattle, hogs, sheep, goats, horses, mules, and asses. These animals, after they were brought from Europe, multiplied with such extraordinary rapidity, that, in 1535, forty-three years after the discovery of the island, the skin had become of equal value with the carcase. Those innumerable herds of cattle, running wild in the woods, are in many parts the rightful prey of the huntsman. In some of the grazing districts one farmer will sometimes own 12,000 head of cattle, which he will sell in herds at the rate of from six to eight dollars *per* head. Hogs are equally numerous with horned cattle, and their flesh is very generally used. The horse, though of a small size, is extremely agile and sure-footed, and goes a gentle ambling pace, well suited to the natural indolence of the inhabitants. The ass and the mule are of an equally good breed. Goats and sheep are bred in great quantities; but the wool has not hitherto become any considerable article of trade. The horses, mules, and asses, at present in the island, are reckoned to amount to 150,000, and the horned cattle to 300,000. There are no deer, and the lama and the vicunna, though abounding in the neighbouring main of South America, have never been transported to the fertile deserts of St Domingo.

Birds, Fishes, Insects.

Wild fowl are abundant, consisting of ducks of a variety of species, namely, the diver, golding, heron, crane, teal, plover, and snipe. On the plains of Neyba is found the flamingo and the wild peacock, which, in flavour, surpasses the finest turkey. No singing birds are to be met with, excepting the Jamaica nightingale, or mocking bird, and the banana bird, with handsome plumage, black and yellow. The Guinea fowl, which is equal in flavour to the wild peacock, is killed in the plains in such quantities, that they are frequently sold in the markets for a rial each. There are four species of wild pigeons, of which the flesh is savoury, though rather bitter; the parrot is also eaten, and the ortolan is abundant.—The fishes caught in the rivers are similar to those in the other islands. The best are the snook, calapever, various kinds of mullet, the pargo, the grooper, Jew fish, baracooter, craw and rock-fish, besides the smaller fry. The land-crab, which burrows in the sand during the day, and issues out at night, is thought a peculiar delicacy. Turtle of all kinds are taken; also immense quantities of tarapins, a small species of amphibious tortoise, which, when dressed, is a rich and delicate food. The serpents are not dreaded; but the centipedes, which are frequent in old buildings, are large and dangerous. The scorpion is rarely seen; but the venomous crab-spider, which is equally formidable, is sometimes met with. St Domingo is annoyed by swarms of noxious insects, the usual plague of all tropical climates. Of these the white ant is the most destructive, as it attacks all kinds of wood, particularly the pine. Packing-boxes of goods, especially when they are made of this wood, are liable to be destroyed by this insect, which enters at one side, and perforates every fold of goods, until it make its way out at the other. Paper is also quickly consumed by it, insomuch that the French, in order to secure the public records, were in the practice of having them regularly copied, and sent to Europe.

Population.

The island of St Domingo was, as already mentioned, divided between the Spaniards and the French; the latter possessing about a fourth part of it, and the remaining three-fourths belonging to the Spaniards. The population of the Spanish division amounted, according to a census taken in 1785, to 152,640. Walton, in his account of the island, estimates the number of inhabitants, in 1810, only at 104,000. He mentions, however, that, when the island was surrendered to France, great numbers of the inhabitants, to the amount he supposes of 25,000, removed to Cuba and other islands. Adding the inhabitants who live in scattered habitations on the mountains, amounting to 8000, and the prisoners and refugees in the neighbouring territories of Hayti, reckoned at 4000, the account of Mr Walton will not be found materially to differ from the original Spanish estimate. Out of the whole population it is calculated that there are 30,000 slaves. The remainder is made up of the mixed races of the white, Indian, and black inhabitants. The European Spaniards are few, and consist chiefly of Catalans, who generally keep shops for the sale of European goods. In 1798, Alcedo, in his *Geographical Dictionary*, estimates the inhabitants at 125,000, of whom 110,000 were free, and 15,000 slaves.

History of the Spanish part of St Domingo.

St Domingo, on its first discovery by the Spaniards, was soon filled with numerous adventurers, who crowded from Europe to the New World, in search of sudden wealth. The industry of those settlers, joined to the exertions of the natives, who were universally reduced to slavery for the benefit of their masters, soon changed the appearance of the country, and, in about twenty years after the first landing of the Spaniards, their settlements were spread over the island; towns and cities were built, and the colony had rapidly increased in prosperity and wealth. But, as St Domingo owed its improvement to the fame of its metallic treasures, which attracted settlers from Europe, it was in its turn abandoned by its inhabitants for other countries of greater reputed wealth. In all the enterprises which were undertaken to the continent of South America, numerous adventurers from St Domingo readily engaged; emigration thus became general, and the mines and sugar works were gradually deserted. From these causes, joined to the misguided and tyrannical policy of the mother country, the colony of St Domingo soon declined; and, in place of yielding, as at first, a revenue to

the Crown, it became necessary, a century after its original settlement, to remit annually from Mexico 300,000 dollars, for the support of the local government.

About the year 1700, the establishment and flourishing state of the French settlements on the island began to revive the interest of the Spanish government in this its neglected and oppressed colony. The rigorous monopoly imposed on its trade was relaxed; new settlers were procured from the Canary Islands, of frugal and laborious habits, and well suited to the climate; encouragements were held out to agriculture and commerce; and, under the influence of these wise measures, the state of the colony soon began to improve; the ruined and deserted towns were rebuilt and peopled, and new settlements were formed; the herds of cattle which ranged over the deserts being now more attended to, rapidly multiplied in the fertile plains of the interior, and an advantageous commerce was begun with the French colony, in which cattle was exported in exchange for slaves and European goods.

The cession of this island to France, which was agreed to by the treaty of Basle, in 1795, gave the first blow to its reviving prosperity. It was not till the latter end of 1801 that the surrender of the island took place, to the representative of the French nation, Toussaint L'Ouverture, who came with a considerable force to repel the expected resistance of the Spanish inhabitants. His entry, however, was not marked by any act of violence or injustice; and, when he retired, the government was delegated to his brother Paul, which he retained till the year 1803. Such, however, was the strong aversion of the Spaniards to the French yoke, that about 25,000 of the inhabitants emigrated, with their slaves, to the continent of South America, and to Cuba, and other islands, from which no consideration could afterwards induce them to return.

In the year 1808, when the inhabitants of St Domingo became acquainted with the general resistance of the mother country to the authority of the French, measures were concerted for their expulsion from the Spanish division of St Domingo. These were attended with such success, that the French commander was speedily shut up, with all his troops, in the town of St Domingo. The siege of this place was commenced, but it had continued, without any prospect of a termination, from November 1808 till July 1809, when a British armament, under General Carmichael, arrived to assist the distressed Spaniards. After some correspondence with the French commander, the place was at length surrendered on the 11th, and the Spanish authority was thus completely re-established in this division of the island.

History of the French part of St Domingo.

The Spaniards retained undisputed possession of the whole of St Domingo till about the middle of the sixteenth century, at which period the island of St Christopher's was taken possession of by a mixed colony of French and English. But this establishment exciting the jealousy of the Spaniards, they attacked the newly planted colony; and those of whom it consisted were either put to death or compelled to seek safety in flight. The barren isle of Tobago, lying off the north-west coast of St Domingo, afforded a refuge to a small number of those adventurers, who, in process of time, grew formidable, under the name of Buccaniers. They at last obtained a firm footing in St Domingo, into which they were previously in the practice of making predatory incursions; and, by the treaty of Ryswick, that part of the island which was occupied by them, as adventurers or pirates, was ceded to the King of France, who acknowledged these colonies as his subjects. They languished for some time under the galling restraints imposed on their trade by the mother country; but these being removed about the year 1722, the colony flourished, and gradually rose to the highest pitch of prosperity. In the year 1789, its produce landed in France amounted in value, before paying any duties, to above six millions Sterling, while the value of goods exported from France was, for the same year, L.4,125,610. Increasing prosperity was visible in the general appearance of the colony; cultivation was every where making rapid advances; the harbours were crowded with shipping, and the towns abounded in all the richest manufactures of Europe.

Such was the state of the French colony in St Domingo, when that memorable revolution commenced, by which such important changes were produced in the mother country. That men were born equal, and were therefore entitled to equal rights, was the great maxim on which the French people founded all their declarations of political freedom; and we may easily imagine, if the propagation of these notions excited a ferment in Europe, what an impression they would make in a community so constituted as that of St Domingo, where every principle of natural right was extinguished in the cruel and degrading bondage of the mass of the people under the tyranny of a few. In St Domingo, as in all the other European colonies, the population is composed of three classes; namely, the whites, the people of colour, and the blacks. Of these the whites were the favoured class, who engrossed all public honours and emoluments, and in whose hands all power centered, both civil and military. No free person of colour was eligible to any public office of trust, honour, or emolument, however insignificant, nor was he allowed to exercise any liberal profession. All naval and military preferments, all degrees in law, medicine, or divinity, were reserved exclusively for the whites. A mulatto could not even follow the vocation of an apothecary or of a schoolmaster, nor, although his father was a white, was he allowed to take his surname, and these disabilities descended in all their rigour to his latest posterity. They were, besides, subjected to military services of an oppressive nature in the militia and other establishments, for which they had neither pay nor allowance of any kind; and if they happened to be aggrieved by any white person, they had no chance of obtaining redress, owing to the partiality with which justice was administered. The free people of colour were in this manner a degraded order; they were marked out by the laws as objects of insult and obloquy, and, as may be easily supposed, they were burning under a sense of their accumulated wrongs. In every West Indian community the slaves naturally form a hostile class, and

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though they are unarmed, their numbers make them formidable. In St Domingo they outnumbered the whites in the proportion of sixteen to one.

Beginning of the Revolution in the French part.

The French colony of St Domingo being in this manner composed of such discordant elements, contained, unfortunately, in its very constitution, the seeds of contention and civil war. The assembling of the States General in the mother country was the signal in the colony for parochial and provincial meetings, which were every where convened. The provincial assemblies differed widely on some important questions, and, in the course of their discussions, a general agitation was excited among all classes. The object of the whites was to establish the political freedom of the colony, while the people of colour boldly claimed, as a first principle of political freedom, their emancipation from bondage, and also a participation, along with the whites, in all political privileges. Several concessions were indeed made by the colonial assemblies, but they fell far short of the demands of the mulattoes, who, being incensed at the disappointment, appeared armed and in large bodies in different parts of the colony. As they acted, however, with little concert, they were easily put down by the regular troops. The first general Colonial Assembly met at St Marc, in April 1790, and they soon afterwards issued a decree new-modelling the government of the colony, and assuming, according to the notions of the governor, powers inconsistent with a due subordination to the mother country. A proclamation was immediately issued by the governor dissolving the assembly, and he dispatched M. Mauduit, Colonel of the regiment of Port-au-Prince, with a detachment of troops, to arrest as traitors some members of the provincial meeting. The assembly, on the other hand, prepared for their defence, and the country was on the eve of being plunged into a civil war, when the members of the General Assembly embraced the sudden and extraordinary resolution of proceeding to France for the purpose of justifying their conduct to the King and to the National Assembly. After their departure, the tranquillity of the colony was interrupted by the rebellion of James Ogé, a mulatto, who, on the notion that the men of colour throughout the colony were ready to rise in insurrection against the whites, presented himself as their leader. But effectual measures were speedily adopted for the suppression of this revolt, and the unfortunate Ogé having escaped to the territories of the Spaniards, was afterwards given up and cruelly broken upon the wheel, while twenty of his followers, and among them his own brother, were hanged.

Mean time the members of the colonial assembly, who had sailed for Europe, were coldly received by the national assembly, and a report of one of its committees was presented, containing the proceedings of the colonial assembly, and declaring them illegal and void; proposing that the assembly should be declared dissolved; that the members then in France should be placed in a state of arrest, and that a new colonial assembly should be summoned. This vacillating policy of the assembly produced the most unhappy effects in the colony, as it favoured the views of those who were attached to the abuses of the old system, while it spread alarm and jealousy through the whole body of the mulattoes. It contributed, in this manner, to divide society more and more into two hostile classes, and to inflame those passions, which a wiser and more steady policy might have soothed into peace. Mean time, those in the mother country who assumed the appellation of the friends of the blacks, and who were too warm in their abstract love of freedom to accommodate their views to any practical standard, were active in propagating their notions; and it was under their influence that, in 1791, a decree was passed, giving to the people of colour the unlimited enjoyment of all the rights which were possessed by French citizens; thus at once breaking down all the distinctions which had prevailed in the colony, and which were sanctioned by custom and inveterate prejudice. This decree was received as might have been expected. It excited among the whites loud and general disapprobation, and they immediately adopted the most violent measures. The national cockade, the badge of their attachment to the revolution, and to the mother country, was openly trampled under foot, and the authority of the Governor General and the supremacy of the mother country were equally set at nought. The several parishes proceeded to the election of a new assembly, which accordingly met on the 9th August, under the title of the General Assembly of the French part of St Domingo. The mulattoes, in the mean time, alarmed at these proceedings, were collecting in armed bodies for their defence, and the whites were so intent on the meeting of the new colonial assembly, that they offered no opposition to these assemblages.

First movements of the Negroes.

Such was the state of affairs between the two hostile classes of the whites and the mulattoes, when a new and more powerful party, whom all united to oppress, now suddenly combined for their own protection and for the destruction of their enemies. On the 23d August reports reached the town of the Cape, that the negro slaves in the neighbouring parishes were in arms, and that they were destroying the plantations and massacring the inhabitants. This terrible intelligence was confirmed next day in its full extent, by crowds of wretched fugitives from the neighbouring country, who, having abandoned their property, were flying to Cape Town from the fury of their savage enemies. The success of this bold and deep laid conspiracy spread universal consternation among the white inhabitants. The citizens in Cape town were immediately summoned to arms. The women and children were at the same time sent on board the ships in the harbour; the domestic negroes in the town were placed under a strong guard, and the free mulattoes, protected from the hatred of the whites by the timely interposition of the governor and colonial assembly were enrolled in the militia, their wives and children being left as hostages for their fidelity. Other measures were also adopted to secure the place against any sudden attack of the infuriated slaves. These precautions being adopted, several small detachments of troops were sent out to act offensively against the insurgents; but although partial successes were obtained in these encounters,

St Domingo. the general result too fatally demonstrated to the white inhabitants their own weakness, and the strength of their enemies, whose fearful superiority of numbers it was evident would finally decide the contest in their favour. In this destructive war it was calculated, that, about two months after its commencement, upwards of 2000 white inhabitants were massacred; that 180 sugar plantations, and about 900 coffee, indigo, and cotton settlements, were destroyed; and 1000 families reduced from opulence to misery. Of the insurgents, about 10,000 are supposed to have perished in the field, and some hundreds by the hands of the public executioner; and the rebellion, which had been hitherto confined to the northern parts of the island, now began to spread through the western districts, where the blacks were aided by the people of colour, and where, under their united devastations, the country was laid waste for an extent of more than thirty miles. At length they approached the town of Port-au-Prince, with the intention of setting it on fire; and it was with great difficulty that a treaty was concluded, by which this place was saved from destruction. This treaty was ratified by the Colonial Assembly, which also announced its intention of granting an extension of privileges to the free people of colour. But, meantime, the National Assembly at home, under an impression of the ruinous consequences of their rash concessions to the people of colour, had voted a repeal of the law which gave them the same privileges as the whites; and the intelligence of this repeal reached the colonies at the time when the Colonial Assembly were holding out the expectation of general equality and freedom. The mulattoes, therefore, when they heard that the National Assembly had repealed their former conciliating act in their favour, imagining that the offer of the whites was an act of concerted treachery to deceive them into a false security, knew no bounds to their indignation; all thoughts of peace were now abandoned; and it was the general sentiment, that the contest could only be terminated by the final extermination of one or other of the hostile parties. The war assumed a diabolical character of cruelty, each studying to outdo the other in acts of revenge. On both sides all prisoners were either massacred without mercy, or reserved for the more solemn barbarity of a public execution.

Progress of the Revolution.

To restore peace to the distracted colony, three civil commissioners were appointed by the National Assembly, who arrived in Cape François in December 1791. But their measures were feeble and indecisive, in no respect suited to allay the ferment which prevailed; and, after a short time, their authority fell into general disrepute. Other decrees were now pronounced by the Assembly at home in favour of the people of colour, and new commissioners were appointed, who arrived in the colony with a force of 8000 men, for the purpose of reducing all classes under the authority of the mother country,—the white inhabitants as well as their revolted slaves. If the former commissioners were tame and inconsistent in their measures, the conduct of the new commissioners was sufficiently arbitrary and decisive. Finding the governor at variance with the Colonial Assembly, one of their first measures was to dissolve the Assembly and to send the governor, under arrest, to France, where he soon afterwards suffered on the scaffold. This was followed by other arrests, which spread terror among the white inhabitants; and the commissioners having at length, by means of liberal donations, secured the troops in their interest, became, in the beginning of the year 1793, absolute masters of the colony. They proceeded to appoint an officer of artillery of the name of Galbaud, governor; but having shortly afterwards differed with him, he was dispossessed of his new office, and ordered to embark for France. The brother of the governor, thus arbitrarily deprived of his dignity, having collected a considerable force, it was resolved to resist the authority of the commissioners. With this view, the two brothers having landed with a force of 1200 seamen, and being immediately joined by other volunteers, proceeded to Cape François to attack the government-house, where the commissioners were posted with a force composed of regulars and people of colour. A fierce and bloody conflict now took place, which terminated without any decisive advantage on either side, and next day the fighting was continued in the streets of the town with various success. In the beginning of these disorders the commissioners had sought to strengthen their party by the aid of the revolted blacks; and a body of these auxiliaries, amounting to about 3000, now entered the place, which immediately became a scene of general conflagration and slaughter. Men, women, and children, were massacred by these barbarians without distinction. The white inhabitants, flying to the sea for protection, were met by a body of armed mulattoes, by whom they were put to the sword without mercy; half of the town was consumed by the flames, and the commissioners, themselves affrighted at these disorders, escaped to the sea-shore, whence, under cover of a ship of the line, they viewed with dismay the wide-spreading mischief.

Ever since the commencement of those unhappy disorders great numbers of the white inhabitants had been emigrating to the neighbouring islands, and to the United States of America. Some of the principal planters had repaired to Great Britain, and by their representations the British government, after some hesitation, was at length induced to send an armament to St Domingo, for the purpose of co-operating with such of the inhabitants as were desirous of placing themselves under its protection. At this period the military force in St Domingo consisted, according to the accurate information of Edwards, of from 14,000 to 15,000 effective white troops. To these were joined the free negroes, mulattoes, and slaves, who were in arms, amounting altogether to 25,000 men, well armed, and trained to some degree of discipline, and inured to the climate. About 100,000 blacks had retired into the mountains of the interior, where they enjoyed a savage independence, and in the northern districts 40,000 slaves still continued in arms. The white inhabitants, also, contrary to the representations which had been made, were extremely hostile to the projected surrender of the colony to Great Britain.

Arrival and departure of a British Armament.

To oppose the regular force of the colony, and the disorderly bands of insurgents scattered throughout

St Domingo. the country, a British force was landed at Jenerine, in September 1793, in the bight of Leogane, on the east coast of the island, amounting to 677 men, which was the first division of the armament destined for St Domingo; the second division, which was on its way, consisting of about 200 troops. The town and harbour were immediately taken possession of, according to a preconcerted arrangement. The fortress and harbour of St Nicholas was also surrendered to a small detachment of troops, which was afterwards reinforced by the second division of the expedition. The town of St Nicholas continued hostile, and most of the inhabitants joined the republican army. An expedition was now undertaken against the neighbouring fort of Tiburon, which was unsuccessful; and, in addition to this disappointment, disease had begun its ravages among the troops; the season of the year was extremely ill chosen for military operations in a tropical climate; the periodical rains were incessant, which, joined to the extraordinary fatigue and hard duty of the troops, exposed them to the fatal scourge of the yellow fever, which now raged among them with unusual malignity. About the end of the year 1793 some inconsiderable reinforcements, amounting to about 800 men, arrived to their aid; and with these, in the beginning of 1794, the port of Tiburon and the fortress of L'Acul were taken, while in other operations the British failed, with loss. A further reinforcement, received in May 1794, led to the important conquest of Port-au-Prince, whose harbour was crowded with trading vessels richly laden. But all these successes were rendered unavailing from the strength and increasing enterprise of the enemy, and still more from the continued ravages of the fever among the British troops. So rapid was the contagion of this fatal disorder, that, of a body of 560 men, which embarked from the Windward Islands, not more than 300 were landed in St Domingo. Upwards of 100 died in the short passage between Guadaloupe and Jamaica, and 150 more were left in a dying state at Port-Royal. After the arrival of this detachment at Port-au-Prince, 40 officers and 600 men were swept off by the virulence of the infection in the short space of two months. Under such deplorable circumstances all hope of further conquest was at an end; a feeble defensive was the system adopted, while the known weakness of the British force gave new vigour and boldness to the enemy. Partial advantages were gained, and brilliant exploits were performed; but it was now manifest, that the defence of the country rested on the solid basis of an armed population, before which the invading force was gradually wasting away. The colonial troops were commanded by Rigaud, a mulatto, an active and enterprising officer, who, though frequently defeated, never ceased renewing his attacks. In the course of the year 1794, he succeeded in taking the town of Leogane, and towards the close of the same year, the important post of Tiburon was carried, after a desperate defence by the garrison. The object of the British was now to strengthen all their defensive positions, and to wait for reinforcements before resuming offensive operations. About the end of the year 1795, 7000 troops arrived under General Howe. But the time for the conquest of this colony was past. The armies of the new kingdom of Hayti were formidable in discipline and numbers, and their leaders were duly sensible of those advantages; so that even with the large reinforcements received, the British commanders could make little impression on the numerous and well organized bodies opposed to them. They were still reduced to act on the defensive, while the enemy was daily growing more confident and enterprising. His posts extended almost to Port-au-Prince, which was still occupied by the English; and he displayed the greatest activity in erecting batteries and fortifications; nor were the British able to give the slightest interruption to these operations, though carried on within four miles of their head-quarters. In 1797, General Simcoe landed in St Domingo as commander of the British force; and about the same time the French government appointed Toussaint L'Ouverture general in chief of the black armies in St Domingo, in whom the British general found an able and indefatigable enemy. During the remainder of the year, hostilities were prosecuted with little vigour on either side. Every prospect of success was now manifestly at an end. The war was, however, protracted till about the middle of the year 1798, when General Maitland, having succeeded General Simcoe in the command, immediately adopted measures for terminating this tedious and destructive contest. He accordingly agreed with the enemy on a month's truce, after which the island was finally evacuated by the English troops.

Administration of Toussaint L'Ouverture.

The first care of Toussaint L'Ouverture, on whom the administration of the country now devolved, was to digest a system of civil policy, suited to the new order of things which had arisen in the colony. The ancient state of manners, which was founded on the peculiar distinctions and privileges of the different classes, had been shaken to pieces in the revolutionary tempests to which those odious distinctions had given rise; and society having slowly emerged from this state of anarchy, had now settled upon the entirely new basis of the freedom and political equality of all ranks. But it was of importance that the blacks should make a right use of their newly acquired freedom—that they should be trained to industry and the mechanical arts—and, above all, that they should regularly cultivate the soil. For this purpose, special regulations were found necessary; and while every possible encouragement was held out to industry, idleness was rendered a political offence, and made liable to certain penalties. The cruelties incident to a state of slavery could no longer be resorted to as a stimulus to industry; but other milder correctives were devised, and these, being duly enforced, were followed by the best effects; so that the ravages of war were gradually repaired: the wasted colony began to revive: and about the autumn of 1801, it was rapidly improving in wealth and happiness under the wise administration of its negro chief. But this gleam of prosperity was unhappily of short duration.

Le Clerc reduces the Negroes.

The war in Europe between Great Britain and France having been concluded by the peace of Amiens, it was

resolved by the chief of the French nation to send out an armament to reduce the revolted colony of St Domingo. A fleet of twenty-six ships of war was collected, into which was embarked an army of 25,000 veteran troops, under the command of General Le Clerc, the brother-in-law of the First Consul. To enter into the details of the barbarous and bloody war now begun against the unfortunate inhabitants of St Domingo, would not be consistent with our limits, nor would they, we are persuaded, be interesting to our readers. It will be sufficient to observe, that the numbers and discipline of the force now landed, joined to the skill of its leaders, overpowered all open resistance in the field; so that the blacks, after several obstinate conflicts, and after burning some of their principal towns, were finally compelled to retire into the inaccessible mountains of the interior, whence they carried on, under their undaunted leader Toussaint, a desultory war against detached parties of their enemies. The negroes and cultivators were either subdued by the terror of the French army, or they were cajoled by the deceitful promises held out by Le Clerc of universal equality and freedom. This general, however, elated by his success, threw off the mask which concealed his real views, and rashly issued an edict proclaiming the former slavery of the blacks. The indefatigable Toussaint was not slow in taking advantage of this error. Having effected a junction with Christophe, who had still 300 troops under him, he descended from the mountains towards the north coast of the island, where there were few French troops, and where the cultivators were numerous. These were no longer deaf to his call, but flocked to his standard in great numbers; and, though badly armed, their numbers and zeal more than made up for this defect. With this collected host, Toussaint poured like a torrent over the whole plain of the north, everywhere forcing the French posts, and driving before him all their detached corps, which were compelled to seek refuge within the walls of Cape François. The town was instantly surrounded; and, to save it from being stormed by the black troops, the French general was compelled to quit his conquests in other parts, and to hasten, by forced marches, to relief. Here he had recourse to his former arts; and having issued a proclamation, containing many fair promises, the black chiefs, who were wearied of the war, agreed to lay down their arms on certain conditions, and to submit to the French authority. The war was in this manner brought to a conclusion; and, by just and liberal measures, the agreement concluded might possibly have been improved into a permanent peace. But the French general, jealous of Toussaint's character and extensive influence, and still suspecting him of being in his heart an enemy to the French, watched his opportunity; and, having privately seized him, along with his family, he was embarked on board a frigate for France, where, being thrown into prison, he languished for some years, and expired in April 1803.

Renewal of the War, and triumph of the Negroes.

This act of cruel treachery spread universal alarm among the black chiefs, who naturally dreaded a similar fate. Dessalines, Christophe, and Clerveaux, were soon found at the head of considerable bodies of troops, and war was renewed with more inveteracy than ever. This last contest for the possession of St Domingo was distinguished by a degree of barbarity which surpasses belief. The whites and the blacks seemed to vie with each other in deeds of cruelty and revenge. Retaliation was the plea still used to sanction every enormity; under which an arrear of vengeance was at length accumulated on both sides, which nothing short of the utter extermination of one of the parties could thoroughly satisfy.

In the course of the year 1802, several actions were fought with various success. Looking, however, generally at the state of the war, it was manifest that the French were losing ground. Their hospitals were crowded with sick, and disease was daily extending its ravages, while the native armies, inured to the climate, were increasing in numbers. In the beginning of the year 1803, the French, exhausted by their losses, were confined within their fortifications, by the vigorous movements of the black armies; and Dessalines, who was now the commander-in-chief, having concentrated his forces in the plain of Cape François, the French general, Rochambeau, was forced to bring together all his troops from every other point, for the defence of the capital. In April 1803, reinforcements arrived from France; but the war, which was about this time renewed between France and Britain, gave the final blow to the French cause in St Domingo. A British blockading squadron soon made its appearance before Cape François; and the French general, thus hemmed in by sea, and closely pressed by his enemies on shore, who threatened to storm the place, had no alternative, but to enter into a capitulation with General Dessalines, by which he agreed to evacuate the whole island. On the 30th November 1803, the standard of the blacks was hoisted on Cape François; and the troops, amounting to about 8000, on evacuating the place, surrendered themselves prisoners of war to the British squadron, by which they were closely watched.

Dessalines assumes the title of Emperor.

Peace being thus once more restored to the country by the valour of its troops, it became necessary to establish some permanent form of government. On the first day of the year 1804, the generals and chiefs of the army accordingly met, and subscribed a formal declaration of independence; all the European names of the island were at the same time discarded, the ancient aboriginal name of Hayti was revived, and Dessalines, whose military talents were in great esteem, was elected governor general for life. The sanguinary character of this chief, now raised to the supreme power, soon began to display itself. His first proclamations breathed a spirit of moderation and peace, but these were soon succeeded by others of a more ferocious character; and at length a general massacre was ordered of all the French inhabitants in the island, which was rigorously executed, without any distinction either of sex or age. Dessalines soon afterwards exchanged the simple title of Governor for the more ostentatious one of Emperor, and, on the 8th October 1804, he was crowned with great pomp. In this situation he began to display all the cruelties of a tyrant, and a conspiracy being in consequence formed against

St Domingo. him by the troops, he was suddenly arrested at head-quarters, and, struggling to escape, he received a blow which terminated his life.

Division of the Sovereignty between Christophe and Petion.

After the death of Dessalines, the two chiefs, Christophe and Petion, assumed the supreme power, and each having a powerful body of adherents, a civil war was the immediate consequence of their rival claims. In this war, which continued for several years, many battles were fought and many lives were lost, but the issue of the struggle was still doubtful, when, in the year 1810, a suspension of hostilities took place; and though no formal treaty was signed, the country has ever since enjoyed all the substantial blessings of peace.

From the year 1811, therefore, the island of St Domingo presents the pleasing picture of domestic prosperity and improvement. Both the chiefs have laboured with the most laudable assiduity for the encouragement of industry and good morals among their subjects. Schools have been established in different parts of the island, where the different branches of education are taught according to the system of Lancaster, and a fund has been appropriated for the erection and endowment of a college, in which professorships are to be established in all the different departments of education and science. The two governments seem to be monarchical in their principles; and Christophe, in imitation of the pomp of other monarchs, has created various orders of nobility, together with numerous officers of state, each of whom has a fixed order of precedence, according to the supposed dignity of their office. Petion, in forming his system of government, rejected the appendage of a titled aristocracy, but he was careful to preserve the gradations of rank, both military and civil; and he was equally intent with Christophe in enlightening his subjects as to their moral duties. It would be very desirable, but it is extremely difficult, to obtain any accurate intelligence as to the cultivation of the island. During the early part of the disturbances, most of the sugar works were consigned to the flames by the infuriated slaves. These have not been since rebuilt, so that very little sugar is now made in the island. The chief produce cultivated is coffee, and, in the year 1805, when the island was under the administration of Dessalines, the crop was calculated at thirty millions of pounds. There was also in the island a considerable quantity of mahogany and other timber. At this period (1805), according to a return made, the inhabitants amounted to 380,000, and the regular army consisted of 13,500 infantry and 1500 cavalry. Since the accession of Louis to the throne of France, various overtures have been made to the governments, both of Christophe and Petion, for the purpose of bringing the colony under the control of the mother-country. But all these overtures, however carefully disguised, and with whatever specious promises introduced, have been rejected with disdain by both the chiefs of this island, who have professed the strongest attachment to their dearly bought independence. It was even proposed to send out a new armament for the purpose of reducing them, when the sudden descent of Bonaparte upon the coast of France interrupted all these measures, and they have never since been renewed. The blacks have, therefore, at length attained their wished for object of independence. All attempts to subdue them have proved entirely unavailing; they have made good their title to freedom by the valour with which they have defended it; and they now remain a standing example of successful revolt to the other negroes. By increased vigilance and increased humanity in the treatment of slaves, the other colonies may still, however, be preserved from the contagion of insurrection. But it cannot be concealed, that the existence of the independent state of Hayti, in the neighbourhood of the other islands, affords an incentive to revolt against which it will be difficult to guard. Such a state of things operates as a strong argument for the strict enforcement of the act prohibiting the importation of additional slaves, as well as for the gentle treatment of those already in the islands. Humanity is the true policy of the West India planter. It is the only principle on which a society so constituted as that of the West India islands can be securely held together. Terror, indeed, may for a time awe the slaves into an unwilling obedience; but aware, as they must be, of their own strength, it is only by ameliorating their condition, and by thus weakening the motives to revolt, that their obedience can be thoroughly secured.

In 1818, Petion died, and the government was peaceably assumed by General Boyer, whom he was allowed to nominate his successor. (O.)

Boundaries.

DONEGAL, anciently called *Tyrconnel*, a county in Ireland, in the province of Ulster, is bounded on the north and west by the Atlantic Ocean, on the east by the counties of Londonderry, Tyrone, and Fermanagh, and on the south by those of Fermanagh and Leitrim, and the bay of Donegal. It is separated from Londonderry and Tyrone by Lough Foyle and the Foyle river, except near the city of Londonderry, the liberties of which extend to the west of the Foyle.

Extent.

Its greatest length is about ninety English miles, the breadth varying from 16 to 45 miles, and it contains about 1,100,000 English acres. Ballyshannon, near its southern extremity, is in latitude 54° 31′ N. and longitude 8° 2.′ W. from Greenwich.

Subdivisions.

The subdivisions are baronies; of which there are six, viz. Raphoe, Kilmacrenan, Ennishowen, Tirhugh, Bannagh, and Boylagh; the two latter, which had been before united, were disjoined by act of Parliament in 1790.

Islands.

There are twenty-two islands called the Rosses, on the north-west coast, of which Arranmore, containing about 1000 English acres, is the largest. Excepting two or three, they are all inhabited.

Surface.

This is a very rugged country, with a cold, wet climate, and, from the want of woods or plantations, much exposed to every blast. A great part of the surface is covered with bogs and mountains. It is nearly divided by a high ridge, that stretches from Tiellen Head on the west, to Tyrone on the east. Yet there is a good deal of fertile land in the vallies between the mountains, and on the banks of the rivers; but there the crops are frequently endangered by floods, which rush impetuously from the high grounds. The western parts of the barony of Tirhugh on the sea, and the barony of Raphoe on the east, comprehend all the champaign country.

Donegal.

Rivers and Lakes.

Besides the Foyle, and the lake of that name, which form the eastern boundary of the county, the principal rivers are the Finn, which traverses a great part of it from west to east, and falls into the Foyle at Strabane; the Erne, which rises from a lake of that name, in the county of Fermanagh, and falls into the sea at Ballyshannon; and the Guibarra, a river of extraordinary breadth and depth for the shortness of its course, reaching the sea on the west, after a course of twenty miles. The fresh water lakes of any note are Lough-Eask and Lough-Derg. Lough-Foyle and Lough-Swilly are arms of the sea; the former navigable for ships of great burden to Londonderry, and for small craft up to Lifford; and the latter carrying vessels of 150 tons to Letterkenny, almost in the centre of the county. Besides these, there is a number of bays, formed by inlets of the sea, from Mulray on the north, to Donegal and Ballyshannon on the south.

Scenery.

Among the natural objects worthy of notice may be mentioned a remarkable glen at Brown-Hall near Ballyshannon. It is watered by a mountain stream which winds through limestone rocks, sometimes above ground, and sometimes concealed from view. The rock in many places is split and much wooded, and the chasm has many bendings and precipices, over which the water is projected with great force, and when swelled by the rains presents a very awful spectacle. A curious phenomenon, called *M'Swine's Gun*, is observed near Hornhead, a headland on the north coast, when the wind blows from that point at half tide. The waves, which have perforated the rock for about twenty yards, rise through an opening in it, not much larger than a kitchen chimney, and ascend into the air with a terrific noise, which may be heard for many miles.

Agriculture.

With the exception of a few farms in the hands of proprietors, and the land in the immediate neighbourhood of the towns, agriculture is in a very backward state in Donegal. The use of the plough is confined to a small proportion of the cultivated land, and is generally of a bad construction: spade labour is preferred in most places. Barley is the chief grain crop, and it is almost all used in distillation; oats are only grown for home consumption, and wheat is confined to a few favourite spots. There are only two flour mills in the county. The culture of flax is considerable in the barony of Raphoe, and is extending even in the mountain districts. Potatoes are cultivated every where. Turnips, clovers, and other green crops, are almost unknown among the tenantry. Village or partnership farms still abound, but farms now begin to be let to individuals as separate holdings. In the low country they are from 10 to 50 acres in extent, and from 40 to 500 in the mountains. The fences are commonly nothing better than ditches, with banks of turf or clay, so that the cattle require to be herded while the crops are growing, and in many parts they are allowed to graze promiscuously as soon as the crops are removed. Sea-weed and shelly sand are used as manures, but very little limestone or limestone gravel. The practice of paring and burning, so common in many parts of Ireland, is seldom resorted to in this county. Leases are granted for 21 years and a life.

Manufactures.

The staple manufacture of Donegal is linen, which has revived since the peace, and continues to extend. In the barony of Boylagh the women are much employed in knitting stockings, which are sold to provide for the rent. Kelp is prepared along the north-west coast; and during the fishing season three or four salt-pans used to be kept in full work. But whisky, says Dr M'Parlan, particularly in the mountain region, and all around the coast, is the chief manufacture. "It is by running their barley into this beverage, that they provide for one-half year's rent. This is therefore a tax raised by the rich on the morals and industry of the poor." In 1814 and 1815, the fines for illicit distillation imposed upon the parish of Culdaff, containing about 4900 inhabitants, amounted to L. 6200.

Fisheries.

The herring fishery, which was at one time very productive on the north-west coast of Donegal, has declined greatly within these few years, though in some seasons it is still considerable. In each of the years 1784 and 1785, the winter fishery produced L. 40,000 to the inhabitants of the Rosses. This induced Colonel Conyngham to form an establishment for prosecuting this fishery on the island of Innismacdurn, one of the Rosses, to which he gave the name of Rutland, after the nobleman of that name, who was then Lord Lieutenant, at an expence to himself of L. 38,000; besides L. 20,000 granted by Parliament. This undertaking was remarkably successful at first, but the herrings have since disappeared, and the whole scheme has entirely failed. The white-fishery is in a great measure neglected. Whales and sun-fish occasionally visit the coast. At Ballyshannon salmon and eels are caught in the Erne, in such numbers as to afford large rents to the owners of these fisheries.

Condition of the People.

The lower orders, especially in the mountain districts, and near the sea coast, are in general miserably lodged; and even where the cabins are somewhat better, they are often intolerably filthy, the cattle and pigs in many cases living in the same apartment with the family. Turf is the only fuel; the common food potatoes and oaten bread. The expence of subsisting a family of six is estimated at L. 15 or L. 16. In the mountain districts, a cabin with an acre of ground and grass for a cow is rented at a guinea a year, by cotters who get 9d. a day for their work, or 6½d. with victuals. In the low country the common rate of wages is 13d. without food, but there the cabin with its appendages rents for two guineas and three pounds.

Education.

A gentleman of the name of Robinson, about 20 years ago, bequeathed a sum of money for the instruction of children of all persuasions, from the interest of which L. 15 was to be paid yearly to a schoolmaster, in each of the parishes in the diocese of Raphoe. The practice is to allow the schoolmaster L. 12, and to lay out the other L. 3 on books. The state of education in the mountain districts is said to be more backward than in any other part of Ireland. The English language is very little known there. The people are anxious to have their children instructed, but are in general too poor to erect schools and support teachers.

In this state of ignorance it is not to be wondered that the people should be addicted to superstitious

Donegal.

observances, some of which cannot well be ascribed to the prevalence of the Catholic religion, though the only one that deserves to be noticed is of that description. On a small island in Lough-Derg, St Patrick's purgatory, as it is called, has been famous for several centuries. Safe-conducts appear to have been granted by the kings of England to foreigners desirous to visit it, in the fourteenth century, some of which have been preserved in Rymer's *Fœdera*. According to Mr Wakefield's information, it is still a place of great resort from June to September. Every pilgrim must remain nine days and as many nights on the island, and pass the last twenty-four hours without food. For the greater part of the day they are on their knees, and, as there are no beds nor shelter of any kind, they sleep under the canopy of heaven. A priest with six assistants attends to direct the penitents in their devotions, and they find it a laborious but very profitable undertaking. There are never fewer than 1000 or 1200 persons assembled on the island while the *station* lasts. From whatever distance they may come, they must travel all the way barefooted and bareheaded. Each is allowed an oaten cake daily for eight days, and for drink they have nothing but the water of the lake, to which they give the name of wine.

St Patrick's Purgatory.

Parishes.

Donegal is in the ecclesiastical province of Armagh, and, according to Beaufort, contained, in 1792, 42 parishes, thirty of which, with thirty-two churches, compose the diocese of Raphoe; 11 parishes and 13 churches are in that of Derry; and one parish with its church in the bishopric of Clogher. The number of parishes all provided with resident clergymen is now 48. All sorts of tillage crops pay tithe, but it is usual to agree for a payment *per* acre in money, which is said to be in general moderate, and obtained without discontent or litigation.

Representation.

Twelve members sat in the Irish Parliament for the county, and the boroughs of Ballyshannon, Donegal, Killybegs, Lifford, and St Johnstown. The county now sends two members to the Parliament of the United Kingdom, but the boroughs none. The number of freeholders, according to Wakefield, is 9000, chiefly Roman Catholics, among whom the Marquis of Abercorn and the Earl of Conyngham have the greatest influence.

Population.

In 1789, the population of Donegal was estimated by Mr Burke of the Royal Irish Academy at 140,000, the number of houses being then 23,521; in 1802, it was supposed to approach 200,000, which is one person for every $5\frac{1}{2}$ English acres. The Catholics are said to be to the Protestants as 6 to 1; the latter are chiefly Presbyterians. Except Lord Southwell, none of the Catholics seem to have landed property; none of them are ever on the grand jury; nor is there a Catholic officer in the county militia. There is no large town in the county. Out of thirty which receive the name of towns, Lifford, where the assizes are held, Ballyshannon, Donegal, Raphoe, Letterkenny, and Rathmelton, are the only places worthy of notice; and none of them require to be particularly described. Small as is the population of this extensive county, it does not afford sufficient employment to its inhabitants. In one year, 4000 have embarked at the port of Londonderry alone for a foreign country, many of them emigrants from this county.

Towns.

Donegal || Dorsetshire.

Changes in its Landed Property.

At the beginning of the seventeenth century, Donegal was possessed by the O'Donnells, O'Doghertys, Macswineys, O'Boyles, Macwards, Macconmeys, O'Gallaghers, and Clerys. The boundaries of the estates that belonged to these families are distinctly marked in a map, called *Ortelius Improved*, copies of which were published in Dublin about twenty years ago. In 1618, a survey was made by Nicholas Pynnar of the six escheated counties of Ulster, which James I. had bestowed chiefly on British settlers, for the purpose of ascertaining if they had complied with the conditions required of them. The extent of these plantations was found to be 500,000 Irish acres (nearly 810,000 English acres), but a great proportion of this was of little value. The landed property of Donegal experienced another revolution after the rebellion of 1641; and it was again surveyed, by Sir William Petty, in 1654, whose map is still preserved by the Commissioners of the Public Records in Ireland. See Beaufort's *Memoir of a Map of Ireland*, 1792; M'Parlan's *Statistical Survey of Donegal*, 1802; Newenham's *View of the Natural, Political, and Commercial Circumstances of Ireland*, 1809; Wakefield's *Account of Ireland, Statistical and Political*, 1812; and the *Parochial Survey of Ireland*, Vol. I. (1814), and Vol. II. (1816.) (A.)

Ancient Names and Divisions.

DORSETSHIRE is an English county on the south-western coast. In British times, and previous to the landing of Cæsar, it was inhabited by the Durotriges and Morini, two appellations derived from the British language, and signifying dwellers on the coasts of the ocean. By the Romans this county constituted a portion of Britannia Prima; and the Saxons called it Dorsetta (a word having the same meaning as the above British appellation), and included it in the kingdom of Wessex. Kingston-Hall and Corfe Castle are mentioned as royal residences.

Boundaries and Extent.

On the north, Dorsetshire is bounded by Somersetshire and Wiltshire; on the east by Hampshire; on the west by Devonshire and a part of Somersetshire; and the British Channel bounds it on the south. The irregularities of its form prevent its being compared to any determinate figure: the northern boundary has a considerable angular projection in the middle; the southern coast runs out in various points and headlands; and the western coast inclines towards Devonshire, with an irregular line. Its greatest length from north to south is about 35 miles; and its breadth from east to west 55; its circumference, including about 775,000 acres, is nearly 160 miles.

Divisions.

Dorsetshire is divided into thirty-four hundreds, containing more than 390 parishes, nine boroughs, and twenty-two market towns; the principal of which are Dorchester, Bridport, Sherborne, Lyme-Regis, Shaftsbury, Wareham, Weymouth, Melcombe Regis, Poole, and Cerne. Twenty members are returned to Parliament by this county, viz. two for the shire, and two for each of the following towns: Dorchester, Poole, Lyme-Regis, Weymouth, Melcombe-Regis, Bridport, Shaftsbury, Wareham, and Corfe-Castle. Dorsetshire is a part of the see of Bristol, though, prior to the dissolution, it had a bishop of its own, being a see of itself; and at different periods was connected with those of Oxford, Winchester, Sherborne, and Sarum.

Surface.

The surface of Dorsetshire is hilly and uneven.

Dorsetshire.

A great portion of the county has the appearance of Downs, open and uninclosed portions, covered with sheep. More sheep are pastured in the neighbourhood of Dorchester than in any other district, though great numbers of both sheep and oxen are fed in the Vale of Blackmore, which is celebrated as rich pasture land, containing upwards of 170,000 acres. There are, also, in this district several orchards, producing excellent cider. On the south-western side, there are many vales of great luxuriance; but on the south-eastern, there is much waste land, dreary and barren, hardly supporting, even in the summer months, a few sheep and cattle, and supplying the neighbouring villages with heath for fuel. Even in this region, however, cultivation is advancing, and detached portions are improved. The turnpike-roads in this county are numerous, rendering travelling easy and commodious.

Soils.

These downs are principally of a light chalky soil, with a turf remarkably fine, producing hay, in the enclosed parts, of an excellent quality, on which beasts will thrive well in winter, without any other food. About Bridport, the lower lands are mostly a deep rich loam; but on the hills, throughout the western district, the soil is a sandy loam, intermixed with flint, well adapted for the growth of beech. To the north of Sherborne, where is some of the best land in the county for the plough, it is a stone brack, which is the case in the Isle of Portland, and the Isle of Purbeck. In the centre of the county the soil is good, and the land well managed.

Timber.

Dorsetshire is not a well wooded county; and, in general, native timber is scarce and dear. In some local spots where the land is cold and wet, such as Duncliff, in the Vale of Blackmore, Heycombe Wood, in the Vale of Sherborne, and others of a similar nature, some plantations may be seen.

Climate.

The air of Dorsetshire is remarkably mild and salubrious; which, added to the beauty of its scenery, has obtained for it the appellation of the Garden of England. Weymouth has long been celebrated as a fashionable watering-place; and, owing to the general calmness of the sea there, its pleasant situation, and its commodiousness for bathing, has, through the frequent visits of the Royal Family, risen to great consequence.

Ports.

There are several good and safe ports in this county; the principal of which are, Poole, Lyme-Regis, and Bridport.

Rivers.

The rivers of Dorsetshire are the Frome, the Stour, the Piddle, and the Ivel. The Frome rises in the north-western part of the county, near Evershot; and, passing by Dorchester, reaches Poole, and falls into its bay. The Stour enters this county from Wiltshire, near Gillingham; and, pursuing a southern and south-eastern direction, enters Hampshire. The Piddle rises in the north, and flowing to the south-east, unites with Poole Bay. The Ivel, anciently Yoo, has its origin from several springs near Horethorn, in a hill north-east from Sherborne, from which town it flows into Somersetshire, and falls into the Parret.

Canal.

The Dorset and Somerset Canal passes through a portion of this county. It has its commencement in the Kennet and Avon Canal at Widbrook near Bradford, and terminates in the Stour river, near Gainscross in Shilling-stone-Okeford. The principal objects of the canal are to supply the manufacturing towns and neighbourhood through which it passes with coals, and to open an inland communication between the Bristol Channel, the Severn, the Thames, and the southern coast of the island. The navigation of this canal is continued from Gainscross, by means of the river Stour, which has been made navigable across the county, and terminates at Christchurch harbour, Hants.

Quarries at Purbeck.

Although neither coal nor any metallic ores have ever been worked in Dorsetshire, the stone quarries of Purbeck and Portland have long been celebrated. Purbeck, though called an island, is more properly a peninsula, of an irregular oval form, about twelve miles in length, and seven in breadth. The soil is altogether calcareous, and for the most part a continued mass, either of white or a brownish limestone; the latter having a mixture of sea-shells. The quarries on the south side of the isle afford an inexhaustible fund of natural curiosities. The best quarries are at Kingston, Worth, Langton, and Swanwick. The Swanwick stone is white, full of shells, takes a good polish, and looks like alabaster. About Wareham and Morden is found a stone of an iron colour, called fire-stone. Near Dunshay, marble of various colours, blue, red, grey and spotted, are dug up; but all of a coarse grain. Much of the stone of this district was used in the building of St Paul's Cathedral, Westminster Bridge, and Ramsgate Pier, and may be discovered in many of our ancient cathedrals, churches, grave-stones, and monuments.

Isle of Portland.

The rocks in the Isle of Portland rise frequently to 100 or 150 feet, and large masses lie scattered on the shore. These are composed of calcareous grit, containing moulds or larox of various shells, and emitting, when rubbed with steel, a bituminous smell. The grit is cemented together by a calcareous paste. The quarries are scattered among these rocks, more or less, in every part of the isle; but those of most repute are at Kingston. At this place is a pier, whence upwards of 6000 tons of stone, on an average, are supposed to be shipped off annually. The first stratum in these quarries is about one foot of blackish or reddish earth; then six feet of stone, not fit for exportation. Below this is the bed of good stone, ten or twelve feet deep, and beneath it flint or clay. The stratum of stone that is worked for sale lies nearly parallel with the upper surface of the island, and without much earth or rubbish on it. When the beds are cleared, the quarrymen proceed to cross-cut the large flats, which is done with wedges. The beds being cut into distinct lumps, are squared by the hammer to the largest size which it will admit; and blocks are thus formed from half a ton to six or eight tons weight. The colour of the Portland stone, or freestone, as it is sometimes called, from the freedom with which it may be broken into any shape, is well known, as almost white, and as composing the materials of the most splendid erections in London, as well as in other parts of the British empire.

Agriculture.

The general practice and management of tillage in this county is less attended to than any part of agri-

Dorsetshire.

culture; for it appears to be the plan of the farmers to put their seed into the ground with as few ploughings as possible. The sowing of wheat is often effected with one ploughing; and symmetry and neatness are so much disregarded, that, in small pieces of land, the ploughman will vary three or four yards from a straight line. The plough used is called a *sull*, and is long, large, and heavy, with one small wheel at the side of the beam, and worked by four horses, or six oxen, two a-breast. In the neighbourhood of the towns, land lets for from forty to fifty shillings the acre; and, in general, arable land from twenty to thirty.

Produce.

Barley is found to make the best returns; and from 10,000 to 12,000 bushels of malt are annually made in some of the towns. Flax and hemp are objects of great importance about Bridport, Bradford, and Beminster. The seed is imported from Riga, and the average crop is from fifty to sixty dozen pounds *per* acre, worth from four shillings and sixpence to seven shillings *per* dozen. It is a precarious crop, depending very much on the season. The seed which is not good enough for sowing is bruised in a mill, and then put into hair-cloths and pressed by a heavy weight, when the linseed-oil used by painters is produced. The hull or husk remaining after the operation is made up into the oil-cake used for feeding cattle.

Sheep.

The sheep of Dorsetshire have long been celebrated. They are horned; white faced; long small white legs; the carcase rather long and thin; the mutton fine grained, and of good flavour; weighing, *per* quarter, in wethers at three years and a half old, from 16 to 20 lbs. Their wool is fine and short; and the breed has the peculiar property of producing lambs at any period: 800,000 is supposed to be the stock of the county, of which number 150,000 are annually sold and sent out of the county. The produce of the wool, yearly, is estimated at 90,000 weight, of thirty-one pounds each.

Horses and Cows.

The breed of horses is not particularly regarded. The oxen are principally of the red Devon breed, crossed with the Hampshire and Wiltshire; and are frequently employed in agriculture. Cows are much used for the dairy, very little account being made of their size or colour if they produce much milk. Butter is the greatest produce, though some cheese is also manufactured.

Fish and Fisheries.

The mackerel fishery is of considerable consequence to this county. Vast numbers are taken near Abbotsbury, and along the shore from Portland to Bridport. The season for taking them is from the middle of March till Midsummer, in nets or seins. Herrings, and other fish common in these seas, are also taken in abundance.

Manufactures.

The manufactures of Dorsetshire are not extensive. The principal are those of flax and hemp, in the neighbourhood of Bridport and Beminster; and also on a smaller scale in the Isle of Purbeck; of all sorts of shirt buttons at Shaftsbury; of a sort of flannel, or coarse woollen cloth called swanskin, at Sherminster. At Stalbridge is a manufacture for spinning silk; and at Sherborne is another upon a larger scale. Some worsted stockings are made at Wimborne.

Dorsetshire.

British Antiquities.

On the extended downs in the neighbourhood of Dorchester, several tumuli are thrown up in all directions, proving this town to have been an important place in British times. Maiden Castle, situated on the apex of a hill about one mile south of the town, is, undoubtedly, the remains of an original British fortress. Nearly two miles north-west of Kingston-Hall, in the parish of Shapwicke, is a celebrated encampment called Bradbury-Rings, which occupies the summit of a considerable eminence. This camp is of a circular form, with treble ramparts and ditches, having two entrances, one on the north-east, and another on the west side. The circumference of the outer rampart is nearly a mile. In the parish of Lullworth is another British fortification, consisting of three ramparts and ditches, including an area of about five acres. It is generally called Flower's Barrow, from the prevalence of these ancient sepulchres within its compass. Many of these barrows have been opened, and found to contain burnt bones, corroded metal, and remains of ancient warlike instruments. A barrow was opened some years ago at Stowborough, in which a body was discovered in an excavated oak trunk, wrapped in folds of skin. Between three and four miles from Corfe Castle eastward, is Nine Barrow Down, an eminence which derives its name from the nine large barrows situated on it in a line. About a mile from Winterbourn Abbas, is a small druidical circle, the diameter of whose area is 28 feet; and the adjacent Downs are much fuller of Celtic barrows than even Salisbury Plains. There is an endless field in many parts of the county for those fond of British antiquities.

Roman Antiquities.

The Via Iceniana, or Icennine Way, enters the county near Woodyates; and passing through Dorchester, takes its course to Seaton in Devonshire. There are several smaller ways proceeding from Dorchester, Winborne, Minster, and some other places in the county. The Roman stations in Dorsetshire appear from the best authorities to have been *Londinis*, now Lyme Regis; *Canca-Arixa*, Charmouth; *Durnovaria*, Dorchester: *Vindogladia*, Winborne; *Clavinio*, Weymouth; *Morinio*, Wareham; and *Bolclannio*, Pole. Near Dorchester are the remains of a Roman amphitheatre, which is computed to have held nearly 13,000 spectators. A large circular entrenchment may be traced upon Woodbury Hill, supposed to have been the *Castra Statica* of the Romans. On Hambledon Hill is another encampment; and the remains of what has been thought to be a labyrinth. In the parish of Rampisham, a beautiful tesselated pavement, about fourteen feet by ten, was discovered in 1799; and in the vale between Maiden-Newton and Frampton, at the distance of 150 yards from the river Frome, another, of much larger dimensions, was found in 1794. At Sturminster-Newton are the ruins of a castle in the form of the letter D.

Castles.

The remains of ancient castles are numerous in Dorsetshire; the principal are the following: Corfe, whose ruins are large, and allowed to be the noblest and grandest in the kingdom; Abbotsbury, a little north of East-Bexington; Brownsea Castle, in the island of the same name; and Portland Castle.

Dorsetshire.

Abbey.

The abbeys whose ruins may yet be discovered, are those of the Monastery of Benedictines at Cranborne, a part of which now forms the parish church, one of the oldest in the county; Cerm Abbey, said to be founded by St Augustine, the remains of which are not many, but interesting; Abbey Milton, whose church is now converted to a private chapel; the Monastery of Shaftsbury, the ruins of which are discernible, near the mansion of Sir Thomas Arundel; some parts of the cloister and domestic buildings of the Abbey of Sherborne are now occupied by silk machinery; besides inconsiderable remains of several more.

Churches.

The church of Fordington is partly in the Saxon style; that of Corfe is Gothic. The churches of Dorchester, Sherborne, Millbourne, St Andrew, Rapisham, Weymouth, and Shaftsbury, are all venerable buildings; but Dorsetshire cannot boast of many instances of ancient ecclesiastical buildings.

Dorchester Jail.

Among the modern erections of this county should be mentioned the new jail of the county town. It was built according to Howard's plan, under the direction of Bradburn the architect. In its external appearance it is peculiarly handsome and characteristic; aud the interior possesses every convenience appropriate to its destination.

Seats.

The principal noblemen and gentlemen's seats of Dorsetshire are; Encombe, of William Moreton Pitt, Esq.; Grange, of John Bond, Esq.; Moer Critchel, of C. Sturt, Esq.; Parnham, of Sir William Oglander, Bart.; Lullworth Castle, of Thomas Wedd, Esq.; Abbey Milton, of the Earl of Dorchester; Sherborne Lodge, of the Earl of Digby; Kingston Hall, of H. Bankes, Esq.; Winterbourne, of E. Williams, Esq.; Wolveton House, the seat of the Trenchard family.

Titles.

This county affords the following titles to different noble families; Earl of Dorchester, to the family of Carleton; Earl of Sherborne, to the family of Dutton; Earl of Shaftsbury, to that of Ashley Cooper; Viscount Bridport, to that of Hood; Duke of Portland, to that of Bentick; Duke of Dorset, to that of Sackville; and Earl Digby, to that of Digby.

Population.

The population of Dorsetshire in 1700 was 90,000; in 1750 it was 96,000; in 1801 it was 119,100; and, according to the returns of 1811, it was as follows:—

Inhabited houses, - -	23,210
Families inhabiting them, -	26,821
Houses building, - -	171
Uninhabited, - - -	841
Families employed in agriculture, -	12,982
In trade, manufactures, and handicraft,	9,607
Not included in the above classes, -	4,232
Total of males, - - -	57,717
——— females, - - -	66,976
Grand total, - - -	124,693
Population of 1801, - -	119,100
Increase, - - -	5,593

See Hutchin's *History of Dorsetshire*; and *Beauties of England and Wales*. (Y. Y.)

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Down.

Boundaries.

DOWN, a county in Ireland, bounded by the Irish sea on the east and south, by the counties of Armagh and Louth on the west, from which it is separated by the rivers Bann and Newry, and by Carrickfergus bay and the county of Antrim on the north. From Point Cranefield in the south, to Grey Point its northern extremity, the distance is nearly 40 Irish, or 51 English miles; but from Lisburn bridge, in the north-west, to Dundrum in the south-east, it is not more than 20 English miles. It contains by estimation 344,658 Irish, or 558,289 English acres, of which 44,658 Irish acres are mountainous and waste. The fifty-fourth degree of north latitude passes close to Cranefield, and the sixth degree of west longitude, a little to the west of Hillsborough.

Divisions.

It is divided into eight baronies, viz. Ardes, Castlereagh, Dufferin, Upper Iveagh, Lower Iveagh, Kinalarty, Lecale, and Mourne, with the Lordship of Newry. It is in the ecclesiastical province of Armagh, and is divided between the dioceses of Dromore and Down; the first occupies the western part of the county, and contains 21 parishes; the second, to the east, forty-two. This is the number of parishes according to Dubourdieu's survey (1802). Beaufort, in 1792, gives only 60; but the latest accounts increase them to 74.

Surface and Scenery.

This county presents a great variety of surface; the plain, the detached hill, ranges of hills, and mountains. The plains are mostly confined to the banks of the rivers; the hills occupy a larger portion; and the lofty mountains are thrown together in the southern quarter, whence they afford a striking feature, and enter into almost every extensive prospect. Here the Mourne mountains, the second in point of height in Ireland, rear their lofty summits. To the north of these, and on the western side, the land is in a high state of cultivation, inhabited by a middle class of manufacturers, and embellished with plantations, bleaching grounds on the rivers Bann and Laggan, and neat whitewashed habitations. The lough of Belfast on the north, with the numerous vessels that resort to it, and the town itself at the bottom, form a most interesting prospect.

Climate and Soil.

The climate is variable, but not subject to extremes. It is seldom long dry in summer, or frosty in winter, and Christmas often finds the fields clothed in green. In spring, the prevailing winds are from the east, nor do they entirely give way to the genial breezes from the south and west till May is far advanced. The highest winds and heaviest rains are from the west. Though the climate is generally salubrious, yet it has been observed that a long course of dry weather in summer, or of frost in winter, is frequently productive of disorders. The soil is of every quality, from sand to strong clay, but the predominant soil is a loam, not of very great depth, but good in quality; and, in most places, intermixed with stones: in the neighbourhood of Moira and Magheralin, on the north-west, it is incumbent on limestone.

Minerals, &c.

Copper and lead have been found in several parts, but no iron or coal. There are several quarries of fine freestone, of different colours, particularly at Scraba near Newtown, and Kilwarlin near the road from Hillsborough to Moira. Slates are wrought near Bangor, on the north, and also at Hillsborough,

Down.

Annahilt, and Ballynahinch. Limestone is not very general; it abounds most near Moira. Granite is chiefly confined to the barony of Mourne, and the Lordship of Newry. Clays of different degrees of fineness, marl, limestone, gravel, and other fossils, are found in many places. Mineral waters, chalybeate, and sulphureous, are numerous, and some of the former strongly impregnated. A chalybeate at Granshaw, in the barony of Ardes, is said to be more than twice the strength of that of Tunbridge.

Rivers.

The principal rivers of this county are the Bann, Laggan, Newry, and Ballynahinch. The Bann has its source in the mountains of Mourne, and after a course of nearly thirty miles, falls into Lough Neagh, near the Bannfoot ferry, in the county of Armagh. Near Portadown it is joined by the Newry canal, which unites the bay of Carlingford with Lough Neagh. The Laggan, which rises from two springs in the mountains of Slieve-Croob and Slieve-na-holy, to the north of the Mourne range, first flows north-west till it nearly reaches the confines of the county, and then winds along its northern boundary, till it is lost in the Lough of Belfast. Pearls were formerly found in both these rivers. Newry rises near Rathfryland towards the west; and, after a short and irregular course, falls into Carlingford bay. The canal which connects this river with the Bann has opened a communication with Lough Neagh, by which vessels of 50 or 60 tons pass through the heart of Ulster. The Ballynahinch has its source in four different streams, each of which issues from a separate lake, and joins Strangford Lough on the south-west.

Estates and Rental.

Though there are some very large estates in this county, property is yet much subdivided, and has all the different gradations, from the most opulent nobleman to the tenant in perpetuity, who farms his own land. Most of it is freehold. The rental was estimated by Dubourdieu, in 1802, at 20s. an Irish acre, for 300,000 acres, allowing for the mountains and bogs, computed at 44,658 acres. Mr Wakefield is of opinion that the rent of these 300,000 acres was double this in 1809, which, being about 25s. the English acre, seems very high over so extensive a territory. It is above the average rental of the best counties in Scotland, as returned to the Commissioners of the Property-tax, in 1811.

Farms.

The farms of this county may be divided into two kinds,—the first, such as are possessed by farmers who have recourse to no other branch of industry,—the second, such as are held by weavers and other tradesmen. The former run from twenty to fifty, and, in some instances, so far as one hundred acres; the latter are of every size from one to twenty acres. The rent is always paid in money; personal services are never exacted. Some leases are for lives and years, others for lives alone. Fences consist chiefly of a ditch and bank, without quicks of any kind, or sometimes with a few plants of furze stuck into the face of the bank; but dry-stone walls are frequent in the stony mountainous parts. Great improvement has been made in its agriculture within these twenty years. Thrashing-mills, and the two horse ploughs of this country have been introduced. But it cannot be said that a good system prevails generally, which the small size of the farms, indeed, renders impracticable. A regular rotation is rarely followed in the crops; fallows, clovers, and turnips, are upon a very small scale; and from the greater part of the arable land, it is still the practice to take crops of grain in succession, only partially interrupted by potatoes, flax, and peas. Oats, the principal grain, are grown on all soils; barley is usually sown after potatoes, and also wheat to some extent on the coast. Of flax they sow four bushels an Irish acre, and the medium produce is fifty stones. Rye and peas occupy but a small space. Lime, marl, shelly-sand, and sea-weed, are used as manures. Paring and burning are confined to the mountains.

Live Stock.

There are extensive meadows on the banks of the Bann and the Laggan; but this is not a grazing county. The soil, except in the mountains, is thought to be better adapted to tillage than pasture. A good many beasts are fatted, but cows are the prevailing stock, kept in small numbers on every farm. They are long-horned, thin in the sides, and deep in the belly, but yield much milk when well fed, and each of them from 60 to as much as 120 lbs. of butter in the year, or about two-thirds of the medium produce of the butter dairies of England. Sheep in flocks of any size are confined to the mountain districts. They are very small, many of them when fat not weighing more than seven or eight pounds a quarter. On the low ground there are a few, seldom exceeding half a score, on almost every farm. A great number of hogs are fattened; many of them bred in the county, but not a few brought from the west of Ireland. The dry hills of this county, covered with heath and odoriferous herbs, are well adapted to bees, but the number of hives has greatly decreased within these twenty years.

Manufactures.

The principal manufacture is linen, which is carried on in all its branches. The number of acres sown with flax in 1809 was 2700, from which it was estimated 3200 bushels of seed would be saved, and the bounty of 5s. a bushel claimed on 3000. According to Mr Wakefield, the twenty bleach-greens on the Bann bleach, on an average, 8000 pieces each, or 160,000 in all, valued at upwards of half a million Sterling; but some of the pieces come from other counties. Such is the perfection to which the art of spinning has been carried by one individual, by name Anne M'Quillin, that she has made 105 hanks out of a pound of flax, the thread thus extending to the astonishing length of 214 miles. In 1802, a weaver earned, for fine linen, from 1s. 4d. to 1s. 6d. *per* day, and, for coarse, from 1s. to 1s. 3d.; but, in 1816, a journeyman weaver got from 1s. 6d. to 2s. and those who bought their own yarn, as much as 3s.

The cotton manufacture is next in importance, though it is but of recent introduction. A great number of workmen from the linen trade soon turned to this new branch, and a great many others, finding it much more easy to learn the weaving of cotton than of linen, and that the wages were better, gave themselves up to cotton entirely. Those who could work in either, however, had the advantage of returning to the linen when there occurred a

Down. stagnation in the cotton trade, as happened a few years ago. Besides muslins, calicoes, blankets, corduroys, and velveteens, are made in various parts. The wages of a good cotton weaver were sometimes more than double the wages of a linen weaver; in 1816, a careful workman earned from 15s. to 21s. a week.

Blankets have been made for more than a century in the vicinity of the village of Lambeg, and here there is an extensive manufactory of papers, of different kinds. A considerable quantity of kelp is made along the coasts, but particularly on the Lough of Strangford, sometimes to the amount of four or five hundred tons, whilst that made on the eastern coast does not exceed one hundred tons. The other manufactures are either for home consumption only, or merely subsidiary to the principal branches. Of the latter description is a manufacture of vitriol at Moyallan, and another on the Down side of Belfast bridge; yet vitriol is still imported from Scotland.

Commerce. The export trade of this county consists of cambrics and linens, butter, pork, grain, and hides. The principal ports are Belfast, a small part of which is in this county, Newry, and Donaghadee; from the last of which great numbers of cattle are transported to Scotland. Its internal trade is greatly facilitated by means of good roads. Sixty years ago, when all journeys were made on horseback, Belfast was considered a week's journey from Dublin; the mail-coaches now carry passengers and heavy luggage over that space in eighteen hours. For the protection of the shipping on the coast there is a light-house at Cross Island, in the barony of Ardes, which is seen distinctly at Portpatrick and the Mull of Galloway, the last of which places is nearly ten leagues distant.

Fisheries. The fisheries on this coast are not so considerable as they might probably become, were more attention bestowed on them. Great quantities of turbot, sole, plaice, cod, and haddock, are caught in Dundrum Bay; and sole, plaice, bret, a few turbot, and, in winter, cod, and excellent oysters, at Bangor. Herrings have been taken in large quantities in Strangford Lough, but they are inferior in fatness and flavour to those caught on the coast.

Towns. The towns in this county are none of them of great extent. Newry is the most considerable for trade, and also of great antiquity, an abbey having been founded there in 1175. In 1689, it was burnt by the Duke of Berwick, to secure his retreat to Dundalk from the English forces, commanded by Duke Schomberg. There is a canal from this town to Lough Neagh. Newry sends a member to the Parliament of the United Kingdom. Hillsborough is a neat modern town, which returned two members to the Irish Parliament. The magnificent residence of the Marquis of Downshire is in its vicinity, and it gives the title of Earl to his family. Bangor also returned two members to the Irish Parliament. Its harbour is deemed safe and commodious. Newton Ardes was another returning borough before the Union. An extensive diaper manufactory has been established in it, and there are two places of worship for dissenters. A monastery was founded here in 1244. Donaghadee consists of two main streets, intersected by cross lanes, and has a quay, constructed in the form of a crescent, 128 yards long. This town is well known to be one of the great thoroughfares between Britain and Ireland, the distance between it and Portpatrick in Scotland being only about ten leagues; and here the packets ply between the two countries. Downpatrick is the county town, consisting of four main streets, and having a barrack, a jail, a court-house, a diocesan school, &c. all spacious and commodious. St Patrick's well, near this town, is highly venerated by the peasantry for its supposed virtues. Downpatrick returns a member to the Imperial Parliament.

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Population, &c. This county contained 19,270 houses in 1751, and 38,351 in 1791. In 1813 there were 38,656 houses and 204,500 inhabitants, which, according to the previous estimate of its contents, allows 2.735 acres to each. About half the population are Catholics, and a great proportion of the other moiety Presbyterians, with Quakers, Methodists, &c. There are 30,000 freeholders who send two members to Parliament, under the influence of the Marquis of Downshire, and, as already mentioned, two more are returned by the boroughs of Downpatrick and Newry. Almost all the people can speak English, but Irish is still much used in the mountains. In the latter district, the condition of the people is not very different from that which has been already noticed under Donegal; but a considerable improvement is observable throughout the rest of the county in their houses, clothes, food, and general character. For common labour, wages are at an average of the year about 1s. *per* day. Turf for fuel is, in many places, very scarce, and coal is, therefore, used in a pretty large proportion, especially in the coast districts.

Antiquities. Among the antiquities of this county, of which there are many, such as cairns, circles of stones, pillars, cromlechs or altar stones, raths with their outworks, and monastic and military ruins, there are, perhaps, none so interesting as the large horns and bones, apparently of the deer kind, found in marl pits, in this and other parts of Ireland. Some of these, dug up in a marl pit near Dromore, in August 1783, are now in the Bishop's possession. The dimensions of the head and horns, measured from tip to tip in a right line, are 10 feet 3 inches, and, following the curve, 14 feet 6 inches. One entire horn is 7 feet 3 inches; the other, of which the point is broken, is 6 feet 9 inches; round the root of the horn 16 inches. The bones of this stately animal were of a suitable magnitude; the head, beginning at the vertebræ, being in length 23 inches, and in breadth at the eyes 11 inches.

See the works referred to under Donegal, and Dubourdieu's *Statistical Survey of Down*, 1802. (A.)

DRAINING. See Part I. Sect. 2. of the article Agriculture in the *Encyclopædia*.

DRAMA.

A DRAMA, (we adopt Dr Johnson's definition, with some little extension,) is a poem or fictitious composition in dialogue, in which the action is not related, but represented.

A disposition to this fascinating amusement, considered in its rudest state, seems to be inherent in human nature. It is the earliest sport of children to take upon themselves some fictitious character, and sustain it to the best of their skill, by such appropriate gesture and language, as their youthful fancies suggest, and such dress and decoration as circumstances place within their reach. The infancy of nations is as prone to this pastime as that of individuals. When the horde emerges out of a nearly brutal state, so far as to have holidays, public sports, and general rejoicings; the pageant of their imaginary deities, or of their fabulous ancestors, is usually introduced as the most pleasing and interesting part of the show. But however general the predisposition to the assumption of fictitious character may be, there is an immeasurable distance betwixt the rude games in which it first displays itself, and that polished amusement which is numbered among the fine arts, which poetry, music, and painting, have vied to adorn; to whose service genius has devoted her most sublime efforts; while philosophy has stooped from her loftier task, to regulate the progress of the action, and give probability to the representation and personification of the scene.

Outline of this Article.

The history of Greece—of that wonderful country, whose days of glory have left such a never-dying blaze of radiance behind them—the history of Greece affords us the means of correctly tracing the polished and regulated drama, the subject of severe rule, and the vehicle for expressing the noblest poetry, from amusements as rude in their outline, as the mimic sports of children or of savages. The history of the Grecian stage is that of the dramatic art in general. They transferred the drama, with their other literature, to the victorious Romans, with whom it rather existed as a foreign than flourished as a native art. Like the other fine arts, the stage sunk under the decay of the empire, and its fall was accelerated by the introduction of the Christian religion. In the middle ages dramatic representation revived, in the shape of the homely Mysteries and Moralities of our forefathers. The revival of letters threw light upon the scenic art, by making us acquainted with the pitch of perfection to which it had been carried by the genius of Greece. With this period commences the history of the modern stage, properly so called. Some general observations on the drama, and its present state in Britain, will form a natural conclusion to the article.

Rise of the Grecian Drama.

The account which we have of the origin of Grecian theatrical representations, describes them as the fantastic orgies of shepherds and peasants, who solemnized the rites of Bacchus by the sacrifice of a goat, by tumultuous dances, and by a sort of masquerade, in which the actors were disguised like the ancient *Morrice-dancers* of England, or the *Guisards* of Scotland, who have not as yet totally disused similar revels. Instead of masks, their faces were stained with the lees of wine, and the songs and jests corresponded in coarseness to the character of the satyrs and fawns, which they were supposed to assume in honour of their patron Bacchus. Music, however, always formed a part of this rude festivity, and to this was sometimes added the recitations of an individual performer, who, possessed of more voice or talent than his companions, was able to entertain an audience for a few minutes by his own individual exertions.

Out of such rude materials, Thespis is supposed to have been the first who framed something like an approach to a more regular entertainment. The actors under this, the first of theatrical managers, instead of running about wild among the audience, were exalted upon a cart, or upon a scaffold formed of boards laid upon tressels. In these improvements Thespis is supposed to have had the aid of one Susarion, whose efforts were more particularly directed to the comic drama. But their fortunes have been unequal, for while the name of Thespis is still united with every thing dramatic, that of Susarion has fallen into oblivion, and is only known to antiquaries.

The drama in Greece, as afterwards in Britain, had scarce begun to develope itself from barbarism, ere, with the most rapid strides, it advanced towards perfection. Thespis and Susarion flourished about four hundred and forty or fifty years before the Christian æra. The battle of Marathon was fought in the year 490 before Christ; and it was upon Eschylus, one of the Athenian generals on that memorable occasion, that Greece conferred the honoured title of the Father of Tragedy. We must necessarily judge of his efforts, by that which he did, not by that which he left undone; and if some of his regulations may sound strange in modern ears, it is but just to compare the state in which he found the drama, with that in which he left it.

Eschylus was the first, who, availing himself of the invention of a stage by Thespis, introduced upon the boards a plurality of actors at the same time, and converted into action and dialogue, accompanied or relieved at intervals by the musical performance of the chorus, the dull monologue of the Thespian orator. It was Eschylus, also, who introduced the deceptions of scenery, stationary, indeed, and therefore very different from the decorations of our stage, but still giving a reality to the whole performance, which could not fail to afford pleasure to those, who beheld for the first time an effort to surround the player, while invested with his theatrical character, with scenery which might add to the illusions of the representations. This was not all: A theatre at first of wood, but afterwards of stone, circumscribed, while it accommodated, the spectators, and reduced a casual and disorderly mob to the

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quality and civilization of a regular and attentive audience.

The most remarkable effect of the tragedy of Eschylus, was the introduction of the chorus in a new character, which continued long to give a peculiar tone to the Grecian drama, and to make a striking difference betwixt that original theatre and those which have since arisen in modern nations.

The chorus, who sung hymns in favour of Bacchus, the musical part, in short, of the entertainment, remained in the days of Thespis, as it had been in the rude village gambols which he had improved, the principal part of the dramatic entertainment. The intervention of monologue, or recitation, was merely a relief to the musicians, and a variety to the audience. Eschylus, while he assigned a part of superior consequence to the actor in his improved dialogue, new-modelled the chorus, which custom still enjoined as a necessary and indispensable branch of the performance. They were no longer a body of vocal musicians, whose strains were as independent of what was spoken by the personages of the drama, as those of our modern orchestra when performing betwixt the acts. The chorus assumed from this time a different and complicated character, which forms a marked peculiarity in the Grecian Drama, distinguishing it from the theatrical compositions of modern Europe.

The chorus, according to this new model, was composed of a certain set of persons, priests, captive virgins, matrons, or others, usually of a solemn and sacred character, the contemporaries of the heroes who appeared on the stage, who remained upon the scene to celebrate in hymns set to music the events which had befallen the active persons of the drama; to afford them alternately their advice or their sympathy; and, at least, to moralize, in lyrical poetry, on the feelings to which their history and adventures, their passions and sufferings, gave rise. The chorus might be considered as, in some degree, the representatives of the audience, or rather of the public, on whose great stage those events happen in reality, which are presented in the mimicry of the drama. In the strains of the chorus, the actual audience had those feelings suggested to them as if by reflection in a mirror, which the events of the scene ought to produce in their own bosom; they had at once before them the action of the piece, and the effect of that action upon a chosen band of persons, who, like themselves, were passive spectators, whose dignified strains pointed out the moral reflections to which the subject naturally gave rise. The chorus were led or directed by a single person of their number, termed the Coryphaeus, who frequently spoke or sung alone. They were occasionally divided into two bands, who addressed and replied to each other. But they always preserved the character proper to them, of spectators, rather than agents in the drama.

The number of the chorus varied at different periods, often extending to fifty persons, and sometimes restricted to *half* that number; and it is evident that the presence of so many persons on the scene officiating as no part of the *dramatis personæ*, but rather as contemporary spectators, involved many inconveniences and inconsistencies. That which the hero, however agitated by passion, must naturally have suppressed within his own breast, or uttered in soliloquy, was thus necessarily committed to the confidence of fifty people, less or more. And when a deed of violence was to be committed, the helpless chorus, instead of interfering to prevent the atrocity to which the perpetrator had made them privy, could only, by the rules of the theatre, exhaust their sorrow and surprise in dithyrambics. But still the union which Eschylus accomplished betwixt the didactic hymns of the chorus, and the events which were passing upon the stage, was a most important improvement upon the earlier drama. By this means, the two unconnected branches of the old Bacchanalian revels were combined together; and we ought rather to be surprised that Eschylus ventured, while accomplishing such an union, to render the hymns sung by the chorus subordinate to the action or dialogue, than that he did not take the bolder measure of altogether discarding that which, before his time, was reckoned the principal object of a religious entertainment.

Grecian Theatre, and mode of Acting.

The new theatre and stage of Athens was reared, as we have seen, under the inspection of Eschylus. He also introduced dresses in character for his principal actors, to which were added embellishments of a kind which mark the wide distinction betwixt the ancient and modern stage. The personal disguise which had formerly been attained by staining the actor's face, was now, by what doubtless was considered as an high exertion of ingenuity, accomplished by the use of a masque, so painted as to represent the personage whom he performed. To augment the apparent awkwardness of this contrivance, the mouths of these masques were frequently fashioned like the extremity of a trumpet, which, if it aided the actor's voice to reach the extremity of the huge circuit to which he addressed himself, must still have made a ridiculous appearance upon the stage, had not the habits and expectations of the spectators been in a different tone from those of a modern audience. The use of the *cothurnus* or buskin, which was contrived so as to give to the performer additional and unnatural stature, would have fallen under the same censure. But the ancient and modern theatres may be said to resemble each other only in name, as will appear from the following account of the Grecian stage, abridged from the best antiquaries.

The theatres of the Greeks were immensely large in comparison to ours; and the audience sat upon rows of benches, rising above each other in due gradation. In form they resembled a horse-shoe. The stage occupied a platform, which closed in the flat end of the building, and was raised so high as to be on a level with the lowest row of benches. The central part of the theatre, or what we call the *pit*, instead of being filled with spectators, according to modern custom, was left for the occasional occupation of the chorus, during those parts of their duty which did not require them to be nearer to the stage. This space was called the ORCHESTRA, and corresponded in some measure with the open space which, in the modern equestrian amphitheatres, is

interposed betwixt the audience and the stage, for the display of feats of horsemanship. The delusion of the scene being thus removed to a considerable distance from the eye of the spectator, was heightened, and many of the objections offered to the use of the masque and the buskin were lessened, or totally removed. When the chorus did not occupy the orchestra, they ranged themselves beside the THYMELE, a sort of altar, surrounded with steps, placed in front of their stage orchestra. From this, as a post of observation, they watched the progress of the drama, and to this point the actors turned themselves when addressing them. The solemn hymns and mystic dances of the chorus, performed during their retreat into the orchestra, formed a sort of interludes, or interruptions of the action similar in effect to the modern division into acts. But, properly speaking, there was no interruption of the representation from beginning to end. The piece was not, indeed, constantly progressive, but the illusion of the scene was always before the audience, either by means of the actors themselves, or of the chorus. And the musical recitation and character of the dances traced by the chorus in their interludes, were always in correspondence with the character of the piece, grave, majestic, and melancholy; in tragedy, gay and lively; in comedy, and during the representation of satirical pieces, wild, extravagant, and bordering on buffoonery. The number of these interludes, or interruptions of the action, seems to have varied from three to six or even more, at the pleasure of the author. The music was simple and inartificial, although it seems to have produced powerful effects on the audience. Two flute players performed a prelude to the choral hymns, or directed the movement of the dances; which, in tragedy, were a solemn, slow, modulated succession of movements, very little resembling anything termed dancing among the moderns.

The stage itself was well contrived for the purposes of the Greek drama. The front was called the LOGEUM, and occupied the full width of the flat termination of the theatre, contracted, however, at each extremity, by a wall, which served to conceal the machinery necessary for the piece. The stage narrowed as it retired backwards, and the space so restricted in breadth was called the PROSCENIUM. It was terminated by a flat decoration, on which was represented the front of a temple, palace, or whatever else the poet had chosen for his scene. Suitable decorations appeared on the wings, as in our theatres. There were several entrances, both by the back scene and in front. These were not used indiscriminately, but so as to indicate the story of the piece, and render it more clear to apprehension. Thus, the persons of the drama, who were supposed to belong to the palace or temple in the flat scene, entered from the side or the main door, as befitted their supposed rank; those who were inhabitants of the place represented, entered through a door placed at the side of the Logeum, while those supposed to come from a distance were seen to traverse the Orchestra, and to ascend the stage by a stair of communication so that the audience were made spectators, as it were, of his journey. The Proscenium was screened by a curtain, which was withdrawn when the piece commenced. The decorations could be in some degree altered, so as to change the scene; though this, we apprehend, was seldom practised. But machinery for the ascent of phantoms, the descent of deities, and similar exhibitions, were as much in fashion among the Greeks as on our own modern stage; with better reason, indeed, for we shall presently see that the themes which they held most proper to the stage called frequently for the assistance of these mechanical contrivances.

In the dress and costume of their personages, the Greeks bestowed much trouble and expence. It was their object to disguise, as much as possible, the mortal actor who was to represent a divinity or an hero; and while they hid his face, and augmented his height, they failed not to assign him a masque and dress in exact conformity to the popular idea of the character represented; so that, seen across the orchestra, he might appear the exact resemblance of Hercules or of Agamemnon.

The Grecians, but in particular the Athenians, became most passionately attached to the fascinating and splendid amusement which Eschylus thus regulated, which Sophocles and Euripides improved, and which all three, with other dramatists of inferior talents, animated by the full vigour of their genius. The delightful climate of Greece permitted the spectators to remain in the open air (for there was no roof to their huge theatres) for whole days, during which several plays, high monuments of poetical talent, were successively performed before them. The enthusiasm of their attention may be judged of by what happened during the representation of a piece written by Hegemon. It was while the Athenians were thus engaged that there suddenly arrived the astounding intelligence of the total defeat of their army before Syracuse. The theatre was filled with the relations of those who had fallen; there was scarce a spectator who, besides sorrowing as a patriot, was not called to mourn a friend or relative. But, spreading their mantles before their faces, they commanded the representation to proceed, and thus veiled, continued to give it their attention to the conclusion. National pride, doubtless, had its share in this singular conduct, as well as fondness for the dramatic art. Another instance is given of the nature and acuteness of their feelings, when the assembly of the people amerced Phrynicus with a fine of a thousand drachmae, because, in a comedy founded upon the siege of Miletos, he had agitated their feelings to excess, in painting an incident which Athens lamented as a misfortune dishonourable to her arms and her councils.

The price of admission was at first one *drachma*, but Pericles, desirous of propitiating the ordinary class of citizens, caused the entrance-money to be lowered to two *oboli*, so that the meanest Athenian had the ready means of indulging in this luxurious mental banquet. As it became difficult to support the expence of the stage, for which such cheap terms of admission could form no adequate fund, the same statesman, by an indulgence yet more perilous, caused the deficiency to be supplied from the treasure destined to sustain the expence of the war. It is a sufficient proof of the devotion of the Athenians to the stage, that not even the elo-

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quence of Demosthenes could tempt them to forego this pernicious system. He touched upon the evil in two of his orations; but the Athenians were resolved not to forego the benefits of an abuse which they were aware could not be justified;—they passed a law making it death to touch upon that article of reformation.

It must not be forgotten, that the Grecian audience enjoyed the exercise of critical authority as well as of classical amusement at their theatre. They applauded and censured, as at the present day, by clapping hands and hissing. Their suffrage, at those tragedies acted upon the solemn feasts of Bacchus, adjudged a laurel crown to the most successful dramatic author. This faculty was frequently abused; but the public, on sober reflection, seldom failed to be ashamed of such acts of injustice, and faithful, upon the whole, to the rules of criticism, evinced a fineness and correctness of judgment, which never descended to the populace of any other nation.

Peculiar Character of the Grecian Drama.

To this general account of the Grecian stage, it is proper to add some remarks on those peculiar circumstances from which it derives a tone and character so different from that of the modern drama—circumstances affecting at once its style of action, mode of decoration, and general effect on the feelings of the spectators.

The Grecian Drama, it must be remembered, derived its origin from a religious ceremony, and, amid all its refinement, never lost its devotional character, unless it shall be judged to have done so in the department of satirical comedy.

When the audience was assembled they underwent a religious lustration, and the archons, or chief magistrates, paid their public adoration to Bacchus, still regarded as the patron of the theatrical art, and whose altar was always placed in the theatre.

The subject of the drama was frequently religious. In tragedy, especially, Sophocles and Euripides, as well as Eschylus, selected their subjects from the exploits of the deities themselves, or of the demi-gods and heroes whom Greece accounted to draw an immediate descent from the denizens of Olympus, and to whom she paid nearly equal reverence. The object of the tragic poets was less to amuse and interest their audience by the history of the human heart, or soften them by the details of domestic distress, as to elevate them into a sense of devotion or submission, or to astound and terrify them by the history and actions of a race of beings before whom ordinary mortality dwindled into pigmy size. This they dared to attempt; and, what may appear still more astonishing to the mere English reader, this they appear in a great measure to have performed. Effects were produced upon their audience which we can only attribute to the awful impression communicated by the idea of the immediate presence of the divinity. The emotions excited by the apparition of the Eumenides, or furies, in Eschylus's tragedy of that name, so appalled the audience, that females are said to have lost the fruit of their womb, and children to have actually expired in convulsions of terror. These effects may have been exaggerated: but that considerable inconveniences occurred from the extreme horror with which this tragedy impressed the spectators, is evident from a decree of the magistrates, limiting the number of the chorus, in order to prevent in future such tragical consequences. It is plain, that the feeling by which such impressions arose, must have been something very different from what the spectacle of the scene alone could possibly have produced. The mere sight of actors disguised in masks, suited to express the terrific yet sublime features of an antique Medusa, with her hair entwined with serpents, the wild and dishevelled appearance, the sable and bloody garments, the blazing torches, the whole apparatus, in short, or properties as they are technically called, with which the classic fancy of Eschylus could invest those terrific personages;—nay more, even the appropriate terrors of language and violence of gesture with which they were bodied forth, must still have fallen far short of the point which the poet certainly attained, had it not been for the intimate and solemn conviction of his audience that they were in the performance of an act of devotion, and to a certain degree, in the presence of the deities themselves. It was this conviction, and the solemn and susceptible temper to which it exalted the minds of a large assembly, which prepared them to receive the electric shock produced by the visible representation of those terrible beings, in whom, whether as personifying the stings and terrors of an awakened conscience, or as mysterious and infernal divinities, the survivors of an elder race of deities, whose presence was supposed to strike awe even into Jove himself, the ancients ascribed the task of pursuing and punishing atrocious guilt.

It was in consistence with this connection betwixt the drama and religion of Greece, that the principal Grecian tragedians thought themselves entitled to produce upon the stage the most sacred events of their mythological history. It might have been thought that, in doing so, they injured the effect of their fable and action, since suspense and uncertainty, so essential to the interest of a play, could not be supposed to exist where the immortal gods, beings controlling all others, and themselves uncontrolled, were selected as the agents in the piece. But it must be remembered, that the synod of Olympus, from Jove downwards, were themselves but limitary deities, possessing, indeed, a certain influence upon human affairs, but unable to stem or divert the tide of fate or destiny, upon whose dark bosom, according to the Grecian creed, gods as well as men were embarked, and both sweeping downwards to some distant, yet inevitable termination of the present system of the universe, which should annihilate at once the race of divinity and of mortality. This awful catastrophe is hinted at not very obscurely by Prometheus, who, when chained to his rock, exults, in his prophetic view, in the destruction of his oppressor Jupiter; and so far did Eschylus, in particular, carry the introduction of religious topics into his drama, that he escaped with some difficulty from an accusation of having betrayed the Eleusinian mysteries.

Where the subject of the drama was not actually taken from mythological history, and when the gods themselves did not enter upon the scene, the Grecian stage was, as we have already hinted, usually trod by beings scarcely less awful to the imagination of the audience; the heroes namely, of their old traditional history, to whom they attributed an im-

 mediate descent from their deities,—a frame of body and mind surpassing humanity, and after death an exaltation into the rank of demigods.

It must be added, that, even when the action was laid among a less dignified set of personages, still the altar was present on the stage; incense frequently smoked; and frequent prayers and obtestations of the deity reminded the audience that the sports of the ancient theatre had their origin in religious observances. It is scarce necessary to state how widely the classical drama, in this respect, differs in principle from that of the modern, which pretends to be nothing more than an elegant branch of the fine arts, whose end is attained when it supplies an evening's amusement, whose lessons are only of a moral description, and which is so far from possessing a religious character, that it has, with difficulty, escaped condemnation as a profane, dissolute, and antichristian pastime. From this difference of principle there flows a difference of practical results, serving to account for many circumstances, which might otherwise seem embarrassing.

The ancients, we have seen, endeavoured by every means in their power, including the use of masks and of buskins, to disguise the person of the actor; and at the expence of sacrificing the expression of his countenance, and the grace, or at least the ease of his form, they removed from the observation of the audience, every association which could betray the person of an individual player, under the garb of the deity or hero he was designed to represent. To have done otherwise would have been held indecorous, if not profane. It follows, that as the object of the Athenian and of the modern auditor in attending the theatre was perfectly different, the pleasure which each derived from the representation had a distinct source. Thus, for example, the Englishman's desire to see a particular character is intimately connected with the idea of the actor by whom it is performed. He does not wish to see Hamlet in the abstract, so much as to see how Kemble performs that character, and to compare him perhaps with his own recollections of Garrick in the same part. He comes prepared to study each variation of the actor's countenance, each change in his accentuation and deportment; to note with critical accuracy the points which discriminate his mode of acting from that of others; and to compare the whole with his own abstract of the character. The pleasure arising from this species of critical investigation and contrast is so intimately allied with our ideas of theatrical amusement, that we can scarce admit the possibility of deriving much satisfaction, from a representation sustained by an actor, whose personal appearance and peculiar expression of features should be concealed from us, however splendid his declamation, or however appropriate his gesture and action. But this mode of considering the drama, and the delight which we derive from it, would have appeared to the Greeks a foolish and profane refinement, not very different in point of taste from the expedient of Snug the joiner, who intimated his identity by letting his natural visage be seen, under the mask of the lion which he represented. It was with the direct purpose of concealing the features of the individual actor, as tending to destroy the effect of his theatrical disguise, that the mask and buskin were first invented, and afterwards retained in use. The figure was otherwise so dressed as to represent the deity or demigod, according to the statue best known, and adored with most devotion by the Grecian public. The mask was by artists who were eminent in the plastic art, so formed as to perfect the resemblance. Theseus, or Hercules, stood before the audience, in the very form with which painters and statuaries had taught them to invest the hero, and there was certainly thus gained a more complete scenic deception, than could have been obtained in our present mode. It was aided by the distance interposed betwixt the audience and the stage; but, above all, by the influence of enthusiasm acting upon the congregated thousands, whose imagination, equally lively and susceptible, were prompt to receive the impressions which the noble verse of their authors conveyed to their ears, and the living personification of their gods and demigods placed before their eyes.

It is scarcely necessary to add, that, while these observations plead their apology for the mask and the buskin of the ancients, they leave, where it stood before, every objection to those awkward and unseemly disguises, considered in themselves, and without reference to the peculiar purpose and tendency of the ancient theatre. In fact, the exquisite pleasure derived from watching the eloquence of feature and eye, which we admire in an accomplished actor, were not, as some have supposed, sacrificed by the ancients for the assumption of these disguises. They never did, and, according to the plan of their theatres, never could, possess that source of enjoyment. The circuit of the theatre was immense, and the eyes of the thousands whom it contained were so far removed from the stage, that, far from being able to enjoy the minute play of the actor's features, the mask and buskin were necessary to give distinction to his figure, and to convey all which the ancients expected to see, his general resemblance, namely, to the character he represented.

The style of acting, so far as it has been described to us, corresponded to the other circumstances of the representation. It affected gravity and sublimity of movement and of declamation. Rapidity of motion, and vivacity of action, seem to have been reserved for occasions of particular emotion; and that delicacy of bye-play, as well as all the aid which look and slight gesture bring so happily to the aid of an impassioned dialogue, were foreign to their system. The actors, therefore, had an easier task than on the modern stage, since it is much more easy to preserve a tone of high and dignified declamation, than to follow out the whirlwind and tempest of passion, in which it is demanded of the performer to be energetic without bombast, and natural without vulgarity.

The Grecian actors held a high rank in the republic, and those esteemed in the profession were richly recompensed. Their art was the more dignified, because the poets themselves usually represented the principal character in their own pieces,—a circumstance which corroborates what we have already stated concerning the comparative inferiority of talents required in a Grecian actor, who was

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only expected to move with grace and declaim with truth and justice. His disguise hid all personal imperfections, and thus a Grecian poet might aspire to become an actor, without that extraordinary and unlikely union of moral and physical powers, which would be necessary to qualify a modern dramatist to mount the stage in person, and excel at once as a poet and as an actor.

Principal Tragic Writers of Athens.

It is no part of our present object to enter into any minute examination of the comparative merits of the three great tragedians of Athens, Eschylus, Sophocles, and Euripides. Never, perhaps, did there arise, within so short a space, such a succession of brilliant talents. Sophocles might, indeed, be said to be the contemporary of both his rivals, for his youthful emulation was excited by the success of Eschylus, and the eminence of his latter years was disturbed by the rivalry of Euripides, whom, however, he survived. To Eschylus, who led the van in dramatic enterprise, as he did in the field of Marathon, the sanction of antiquity has ascribed unrivalled powers over the realms of astonishment and terror. At his summons, the mysterious and tremendous volume of destiny, in which are inscribed the doom of gods and men, seemed to display its leaves of iron before the appalled spectators; the more than mortal voices of Deities, Titans, and departed Heroes, were heard in awful conference; heaven bowed, and its divinities descended; earth yawned, and gave up the pale spectres of the dead; and the yet more undefined and grisly forms of those infernal deities who struck horror into the gods themselves. All this could only be dared and done by a poet of the highest order, confident, during that early age of enthusiasm, that he addressed an audience prompt to kindle at the heroic scene which he placed before them. It followed almost naturally, from his character, that the dramas of Eschylus, though full of terrible interest, should be deficient in grace and softness; that his sublime consciseness should deviate sometimes into harshness and obscurity;—that, finding it impossible to sustain himself at the height to which he had ascended, he should sometimes drop, "fluttering his pinions vain," into great inequalities of composition; and, finally, that his plots should appear rude and inartificial, contrasted with those of his successors in the dramatic art. Still, however, Eschylus led not only the way in the noble career of the Grecian drama, but outstripped, in point of sublimity at least, those by whom he was followed.

Sophocles, who obtained from his countrymen the title of the *Bee* of Attica, rivalled Eschylus when in the possession of the stage, and obtained the first prize. His success occasioned the veteran's retreat to Sicily, where he died, commanding that his epitaph should make mention of his share in the victory of Marathon, but should contain no allusion to his dramatic excellencies. His more fortunate rival judiciously avoided the dizzy and terrific path which Eschylus had trode with so firm and daring a step. It was the object of Sophocles to move sorrow and compassion, rather than to excite indignation and terror. He studied the progress of action with more attention than Eschylus, and excelled in that modulation of the story by which interest is excited at the beginning of a drama, maintained in its progress, and gratified at its conclusion. His subjects are also of a nature more melancholy and less sublime than those of his predecessor. He loved to paint heroes rather in their forlorn than in their triumphant fortunes, aware that the contrast offered new sources of the pathetic to the author. Sophocles was the most fortunate of the Greek tragedians. He attained the age of ninety-one years; and, in his eightieth, to vindicate himself from a charge of mental imbecility, he read to the Judges his *Œdipus Coloneus*, the most beautiful, at least the most perfect, of his tragedies. He survived Euripides, his most formidable rival, of whom, also, we must speak a few words.

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It is observed by Schlegel, that the tone of the tragedies of Euripides approaches more nearly to modern taste than to the stern simplicity of his predecessors. The passion of love predominates in his pieces, and he is the first tragedian who paid tribute to the passion which has been too exclusively made the moving cause of interest on the modern stage,—the first who sacrificed to

Cupid, king of gods and men.

The dramatic use of this passion has been purified in modern times, by the introduction of that tone of sentiment which, since the age of chivalry, has been a principal ingredient in heroic affection. This was unknown to the ancients, in whose society females, generally speaking, held a low and degraded place, from which few individuals emerged, unless those who aspired to the talents and virtues proper to the masculine sex. Women were not forbidden to become competitors for the laurel or oaken crown offered to genius and to patriotism; but antiquity held out no myrtle wreath, as a prize for the domestic virtues peculiar to the female character. Love, therefore, in Euripides, does not always breathe purity of sentiment, but is stained with the mixture of violent and degrading passions. This, however, was the fault of the age, rather than of the poet, although he is generally represented as an enemy of the female sex; and his death was ascribed to a judgment of Venus,

When blood-hounds met him by the way,
And monsters made the bard their prey.

This great dramatist was less happy than Sophocles in the construction of his plots; and, instead of the happy expedients by which his predecessor introduces us to the business of the drama, he had too often recourse to the mediation of a prologue, who came forth to explain, in detail, the previous history necessary to understand the piece.

Euripides is also accused of having degraded the character of his personages, by admitting more alloy of human weakness, folly, and vice, than was consistent with the high qualities of the heroic age. Eschylus, it was said, transported his audience into a new and more sublime race of beings; Sophocles painted mankind as they ought to be, and Euripides as they actually are. Yet the variety of character introduced by the latter tragedian, and the interest of his tragedies, must always attract the modern reader, coloured as they are by a tone of sentiment and by his knowledge of the actual business, rules, and habits, of actual life, to which his predecessors, living as

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they did, in an imaginary and heroical world of their own, appear to have been strangers. And although the judgment of the ancients assigned the pre-eminence in tragedy to Eschylus or Sophocles, yet Euripides has been found more popular with posterity than either of his two great predecessors.

Grecian Comedy.

The division betwixt tragedy and comedy, for both sprung from the same common origin. the feasts, namely, in honour of Bacchus, and the disguises adopted by his worshippers, seems to have taken place gradually until the jests and frolics, which made a principal part of these revels, were found misplaced when introduced with graver matter, and were made by Susarion, perhaps, the subject of a separate province of the drama. The Grecian comedy was divided into the ancient, the middle, and the modern, style of composition.

Ancient Comedy.

The ancient and original comedy was of a kind which may, at first sight, appear to derogate from the religious purposes which we have pointed out as the foundation of the drama. They frequently turn upon parodies, in which the persons and adventures of those gods and heroes who were the sublime subjects of the tragic drama, are introduced for the purpose of buffoon-sport, and ridicule, as in Carey's modern farces of *Midas* and the *Golden Pippin*. Hercules appears in one of those pieces astonishing his host by an extravagant appetite, which the cook in vain attempts to satiate, by placing before him, in succession, all the various dishes which the ancient kitchen afforded. In another comedy, Bacchus (in whose honour the solemnity was instituted) is brought in only in order to ridicule his extreme cowardice.

At other times, allowing a grotesque fancy its wildest range, the early comic authors introduced upon the stage animals, and even inanimate things, as part of their *dramatis personæ*, and embodied forth on the stage, the fantastic imaginations of Lucian in his *True History*. The golden age was represented in the same ridiculous and bizarre mode of description as the *Pays de la Cocagne* of the French minstrels, or the popular ideas of *Lubber-land* in England: and the poets furnished kingdoms of birds and worlds in the moon.

Had the only charm of these entertainments consisted in the fantastic display with which the eyes of the spectators were regaled at the expence of the over-excited imagination of the poet, they would soon have fallen into disuse; for the Athenians were too acute and judicious critics, to have been long gratified with mere extravagance. But these grotesque scenes were made the medium for throwing the most bold and daring ridicule upon the measures of the state, upon the opinions of individuals, and upon the religion of the country.

This propensity to turn into ridicule that which is most serious and sacred, had probably its origin in the rude gambols of the sylvan deities who accompanied Bacchus, and to whose petulant and lively demeanour rude jest was a natural accompaniment. The audience, at least the more ignorant part of them, saw these parodies with pleasure, which equalled the awe they felt at the performance of the tragedies, whose most solemn subjects were thus burlesqued; nor do they appear to have been checked by any sense that their mirth was profane. In fact, when the religion of a nation comes to consist chiefly in the practice of a few unmeaning ceremonies, it is often found that the populace, with whatever inconsistence, assume the liberty of profaning them by grotesque parodies, without losing their reverence for the superstitions which they thus vilify. Customs of a like tendency were common in the middle ages. The festival of the Ass in France, of the Boy-Bishop in England, of the Abbot of Unreason in Scotland, and many other popular practices of the same kind, exhibited, in countries yet Catholic, daring parodies of the most sacred services and ceremonies of the Roman Church. And as these were practised openly, and under authority, without being supposed to shake the people's attachment to the rites which they thus ridiculed, we cannot wonder that similar profanities were well received among the Pagans, whose religion sat very loosely upon them, and who professed no fixed or necessary articles of faith.

It is probable, that, had the old Grecian comedy continued to direct its shafts of ridicule only against the inhabitants of Olympus, it would not have attracted the coercion of the magistracy. But its kingdom was far more extensive, and the poets claiming the privilege of laying their opinions on public affairs before the people in this shape. Cratinus, Eupolis, and particularly Aristophanes, a daring, powerful, and apparently unprincipled writer, converted comedy into an engine for assailing the credit and character of private individuals, as well as the persons and political measures of those who administered the state. The doctrines of philosophy, the power of the magistrate, the genius of the poet, the rites proper to the Deity, were alternately made the subject of the most uncompromising and severe satire. It was soon discovered, that the more directly personal the assault could be made, and the more revered or exalted the personage, the greater was the malignant satisfaction of the audience, who loved to see wisdom, authority, and religious reverence, brought down to their own level, and made subjects of ridicule by the powers of the merciless satirist. The use of the mask enabled Aristophanes to render his satire yet more pointedly personal; for, by forming it so as to imitate, probably with some absurd exaggeration, the features of the object of his ridicule, and by imitating the dress and manner of the original, the player stepped upon the stage, a walking and speaking caricature of the hero of the night, and was usually placed in some ludicrous position, amidst the fanciful and whimsical chimeras with which the scene was peopled.

In this manner, Aristophanes ridiculed with equal freedom Socrates, the wisest of the Athenians, and Cleon, the demagogue, when at the height of his power. As no one durst perform the latter part, for fear of giving offence to one so powerful, the author acted Cleon himself, with his face smeared with the lees of wine. Like the satire of Rabelais, the political and personal invective of Aristophanes was mingled with a plentiful allowance of scurril and indecent jests, which were calculated to insure a favourable reception from the bulk of the people. He resembles Rabelais, also, in

the wild and fanciful fictions which he assumes as the vehicle of his satire; and his comedy of the Birds may even have given hints to Swift, when, in order to contrast the order of existing institutions with those of an Utopian and fantastic fairy land, he carries Gulliver among giants and pigmies. Yet though his indecency, and the offensive and indiscriminate scurrility of his satire, deserve censure; though he merits the blame of the wise for his attack upon Socrates, and of the learned for his repeated and envenomed assaults on Euripides, Aristophanes has nevertheless added one deathless name to the deathless period in which he flourished; and, from the richness of his fancy, and gaiety of his tone, has deserved the title of the Father of Comedy. When the style of his sarcasm possessed the rareness of novelty, it was considered of so much importance to the state, that a crown of olive was voted to the poet, as one who had taught Athens the defects of her public men. But unless angels were to write satires, ridicule cannot be considered as the test of truth. The temptation to be witty is just so much the more resistless, that the author knows he will get no thanks for suppressing the jest which rises to his pen. As the public becomes used to this new and piquant fare, fresh characters must be sacrificed for its gratification. Recrimination adds commonly to the contest, and those who were at first ridiculed out of mere wantonness of wit, are soon persecuted for resenting the ill usage; until literature resembles an actual personal conflict, where the victory is borne away by the strongest and most savage, who deals the most desperate wounds with the least sympathy for the feeling of his adversary.

The ancient comedy was of a character too licentious to be long tolerated. Two or three decrees having been in vain passed, in order to protect the citizens against libels of this poignant description, the ancient comedy was finally proscribed by that oligarchy, which assumed the government of Athens, upon the downfal of the popular government towards the end of the Peloponnesian war. By order of these rulers, Anaxander, an actor, was punished capitally, for parodying a line of Euripides, so as to infer a slight of the government. He was starved to death, to which, as an appropriate punishment, the public has since his time often indirectly condemned both actors and dramatists. Aristophanes, who was still alive, bowed to the storm, and relinquished the critical and satirical scourge, which he had hitherto exercised in the combined capacity of satirist, reformer, and reviewer; and the use of the chorus was prohibited to comic authors, as it seems to have been in their stanzas chiefly that the offensive satire was invested. To this edict Horace alludes in the well known lines:

> "Successit vetus his comedia, non sine multâ
> Laude, sed in vitium libertas excidit, et vim
> Dignam lege regi: lex est accepta: chorusque
> Turpiter obticuit, sublato jure nocendi." *

Middle Comedy.

In the middle comedy, Thalia and her votaries seemed to have retraced their steps, and, avoiding personal satire, resorted once more to general subjects of burlesque raillery. We learn from history, real or fabulous, or from the works of the elder poets, that these plays had the fanciful wildness without the personal satire of the ancient comedy, for the authors were obliged to take care that there was no "offence" in their pleasantry. At most, they only ventured to touch on matters of instant interest in the way of inuendo, under feigned titles and oblique hints, and had no longer the audacity to join men's vices or follies to their names. Aristophanes re-cast several of his pieces in this manner. But the same food, without the poignant seasoning to which the audience had been accustomed, palled on their taste, and this cast of pieces soon gave place to that which the ancients called the New Comedy, so successfully cultivated by Menander and others.

Notwithstanding what modern critics have said to the contrary, and particularly the ingenious Schlegel, the new tone which comedy thus assumed, seems more congenial to true taste as well as to public decorum, and even to the peace and security of the community, than that of Aristophanes, whose satiric wit, like a furious bull, charged upon his countrymen without respect or distinction, and tossed and gored whatever he met with in his way.

New Comedy.

The new comedy had for its object the ludicrous incidents of private life,—*celebrare domestica facta*, says Horace,—to detail those foibles, follies, and whimsical accidents, which are circumstances material and serious to the agents themselves, but, as very usually happens on the stage of the world, matters only of ludicrous interest to the on-lookers. The new comedy admitted also many incidents of a character not purely ludicrous, and some which, calling forth pathetic emotion, approached more nearly to the character of tragedy than had been admitted in the ancient comedies of Aristophanes, and in this rather resembled what the French have called *Tragedie Bourgeoise*. It is scarce necessary to remark, that the line cannot be always distinctly drawn betwixt the subjects which excite mirth and those which call forth sympathy. It often happens that the same incident is at once affecting and ludicrous, or admits of being presented alternately in either point of view. In a drama, also, which treats of the faults and lighter vices, as well as of the follies of mankind, it is natural that the author should sometimes assume the high tone of the moralist. In these cases, to use the language of Horace,

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* The ancient comedy next play'd its part,
Well-famed, at first, for spirit and for art;
But Liberty o'erleaping decent awe,
Satiric rage required restraint from law,
The edict spoke,—dishonour'd silence bound
The chorus, and forbade their ancient right to wound.

Drama. comedy exalts her voice, and the offended father, the pantaloon of the piece, swells into sublimity of language. A pleasant species of composition was thus attained, in which wit and humour were relieved by touches both of sentiment and moral instruction. The new comedy, taken in this enlarged point of view, formed the introduction to the modern drama; but it was neither so comprehensive in its plan, nor so various in character and interest.

General Character of the New Comedy.

The form which the Greeks, and in imitation of them the Romans, adopted, for embodying their comic effusions, was neither extended nor artificial. To avoid the charge of assaulting, or perhaps the temptation to attack private persons, the actors in their drama were rather painted as personifications of particular classes of society, than living individual characters. The list of these personages was sufficiently meagre. The principal character, upon whose devices and ingenuity the whole plot usually turns, is the *Geta* of the piece, a witty, roguish, insinuating and malignant slave, the confident of a wild and extravagant son, whom he aids in his pious endeavours to cheat a suspicious, severe, and griping father. When to these three are added, a wily courtezan, a procuress, a stolen virgin, who is generally a mute or nearly such, we have all the stock-characters which are proper to the classic comedy. Upon this limited scale of notes the ancients rung their changes, relieving them occasionally, however, by the introduction of a boastful soldier, a boorish clown, or a mild and good natured old man, to contrast with the irascible Chremes of the piece, the more ordinary representative of old age.

The plot is in general as simple as the cast of the characters. A father loses his child, who falls into the hands of a procuress or slave merchant. The efforts of the youth, who falls in love with this captive, to ransom her from her captivity, are seconded by the slave, who aids him in the various devices necessary to extort from his father the funds necessary for the purchase, and their tricks form the principal part of the intrigue. When it is necessary that the play shall close, the discovery of the girl's birth takes place, and the young couple are married. The plots are, indeed, sometimes extended or enlarged by additional circumstances, but very seldom by any novelty of character or variety of general form.

It is a necessary consequence, that the ancient comic authors were confined within a very narrow compass. The vast and inexhaustible variety of knavery, folly, affectation, humour, &c. &c. as mingled with each other, or as modified by difference of age, sex, temper, education, profession and habit of body, are all within the royalty of the modern comic dramatist, and he may summon them up under what limitations, and in what circumstances he pleases, to play their parts in his piece. The ancients were much more limited in their circle of materials, and, perhaps, we must look for the ruling cause, once more, in the great size of their theatres, and to the use of the mask; which, though it easily presented the general or generic character of the personage introduced, was incapable of the endless variety which can be given to ridicule of a more minute, refined, and personal kind, by the flexible organs of a modern actor.

But besides this powerful reason for refraining from any attempt to draw characters distinguished by peculiar habits, there is much reason to think that the mode of life pursued by the ancient Athenians, was unfavourable to the formation of whimsical, original, or eccentric characters. Citizens of the same state, they lived much together, and the differences of ranks did not make the same distinction in taste and manners as in modern Europe. Their occupation, also, was the same. They were all public men, and had a common interest in the management of the state; and it probably followed that, in men whose pursuits were all bent the same way, the same general similarity of manners might be found to exist, which is remarked in those who follow the same profession. The differences of youth and age, of riches and poverty, of good or bad temper, &c. must have been much modified in Attica, where all free citizens were, to a certain degree, on a level,—discussed the same topics of state, and gave the same vote to forward them,—enjoyed, without restriction, the same public amusements; and where the same general cast of manners might descend to the lowest of the citizens, for the very reason that even a poor herb-woman understood the delicacy of the Attic dialect so perfectly, as to distinguish a stranger by the first words he addressed to her.

The chorus, silenced, as we have seen, owing to the licence of the old comedy, made no appendage to that which was substituted in its place. The exhibition of the Grecian comedy did not, in other respects, in so far as we know, materially differ from that of the tragedy. Instead of the choral interludes, the representation was now divided, by intervals of cessation, into acts, as upon the modern stage. And the number five seems to have been fixed upon as the most convenient and best adapted for the purposes of representation. The plot, as we have seen, and the distinct and discriminated specification of character, were, in either case, subordinate considerations to the force of style and composition. It follows, of consequence, that we can better understand and enjoy the tragedies than the comedies of the ancients. The circumstances which excite sublime or terrific sensations are the same, notwithstanding the difference of age, country, and language. But comic humour is of a character much more evanescent. The force of wit depends almost entirely upon time, circumstance, and manners, in so much, that a jest which raises inextinguishable laughter in a particular class of society, appears flat or disgusting if uttered in another. It is, therefore, no wonder that the ancient comedy, turning upon manners so far removed from our own time, should appear to us rather dull and inartificial. The nature of the intercourse between the sexes in classic times was also unfavourable for comedy. The coquette, the fine lady, the romp, all those various shades of the female character, which occupy so many pleasant scenes on the modern stage, were totally unknown to ancient manners. The wife of

the ancient comedy was a mere household drudge, the vassal, not the companion, of an imperious husband. The young woman whose beauty is the acting motive of the intrigue, never evinces the slightest intellectual property of any kind. And the only female character admitting of some vivacity, is that of the courtezan, whose wit as well as her charms appeared to have been professional.

After subtracting the large field afforded by female art or caprice, female wit, or folly, or affection, the realm of the ancient comedy will appear much circumscribed; and we have yet to estimate a large deduction to be made on account of the rust of antiquity, and the total change of religion and manners. It is no wonder, therefore, that the wit of Plautus and Terence should come forth diminished in weight and substance, after having been subjected to the alembic of modern criticism. That which survives the investigation, however, is of a solid and valuable character. If these dramas do not entertain us with a display of the specific varieties of character, they often convey maxims evincing a deep knowledge of human passion and feeling; and are so admirably adapted to express, in few and pithy words, truths which it is important to remember, that even the Apostle Paul himself has not disdained to quote a passage from a Grecian dramatist. The situation, also, of their personages is often truly comic; and the modern writers who have borrowed their ideas, and arranged them according to the taste of their own age, have often been indebted to the ancients for the principal cause of their success.

Roman Drama.

Having dwelt thus long upon the Grecian Drama, we are entitled to treat with conciseness that of Rome, which, like the other fine arts, that people, rather martial than literary, copied from their more ingenious neighbours.

The Romans were not, indeed, without a sort of rude dramatic representation of their own, of the same nature with that which, as we have already noticed, usually arises in an early period of society. These were called *Fabulæ Atellanæ;* farces, for such they were, which took their name from *Atella,* a town belonging to the *Osci* in Italy. They were performed by the Roman youth, who used to attack each other with satirical couplets during the intervals of some rude game, in which they seem to have represented the characters of fabulous antiquity. But 361 years before the Christian æra, the Romans, in the time of a great pestilence, as we learn from Livy, introduced a more regular species of theatrical entertainment, in order to propitiate the deities by a solemn exhibition of public games; after which, what had hitherto been matter of mere frolic and amusement, assumed, according to the historian, the appearance of a professional art; and the Roman youth who had hitherto appeared as amateur performers, gave up the stage to regular performers.

These plays continued, however, to be of a very rude structure, until the Grecian stage was transplanted to Rome. Livius Andronicus, by birth a Grecian, led the way in this improvement, and is accounted her first dramatist.

Seneca the philosopher is the only Roman tragedian whose works have reached our time. His tragedies afford no very favourable specimen of Roman art. They are in the false taste which succeeded the age of Augustus, and debased the style of composition in that of Nero; bombastic, tedious, and pedantic; treating, indeed, of Grecian subjects, but not with Grecian art.

By a singular contrast, although we have lost the more valuable tragedies of Rome, we have been compelled to judge of the new Greek comedy, through the medium of the Latin translations. Of Menander we have but a few fragments, and our examples of his drama are derived exclusively from Plautus and Terence. Of these, the former appears the more original, the latter the more elegant author. The comedies of Plautus are much more connected with manners,—much more full of what may be termed drollery and comic situation —and are believed to possess a greater portion of Roman character. The Romans, indeed, had two species of comedy, the *Palliata,* where the scene and dress were Grecian; the *Togata,* where both were Roman. But besides this distinction, even the *Mantled,* or Grecian comedy, might be more or less of a Roman cast; and Plautus is supposed to have infused a much stronger national tone into his plays than can be traced in those of Terence. They are also of a ruder cast, and more extravagant, retaining, perhaps, a larger portion of the rough horse-play peculiar to the *Fabulæ Atellanæ.* Terence, on the contrary, is elegant, refined, and sententious; decorous and regular in the construction of his plots; exhibiting more of wit in his dialogue, than of comic force in his situations; grave often and moral; sometimes even pathetic; and furnishing, upon the whole, the most perfect specimens of the Grecian comedy, both in action and character.

The alterations which the Romans made in the practice of the theatrical art do not seem to have been of great consequence. One circumstance, however, deserves notice. The orchestra, or, as we should say, the pit of the theatre, was no longer left vacant for the occasional occupation of the chorus, but was filled with the senators, knights, and other more respectable citizens. The stage was thus brought more near to the eye of the higher class of the audience. It would also seem that the theatres were smaller; for we read of two so constructed, that each turned upon a pivot, so that, when placed back to back, they were separate theatres, yet were capable of being wheeled round, with all the audience, so as to bring their oblong ends together, then forming a single amphitheatre, in which the games of the circus succeeded to dramatic representation. It is not easy to conceive the existence of such machinery; but the story, at any rate, seems to show, that their theatres must have been greatly smaller than those of Greece, to admit the supposition of such an evolution as being in any degree practicable. This diminution in the size of the house, and the occupation of the orchestra by the most dignified part of the audience, may have afforded a reason why masks were, at least, occasionally, disused on the Roman stage. That they were sometimes disused is certain;

for Cicero mentions Roscius Gallus as using a mask to conceal a deformity arising from the inequality of his eyes, which implies plainly that other comedians played with their faces disclosed. It is therefore probable, that the imperfections of the mask were felt, so soon as the distance was diminished between the performer and the spectators; and we may hazard a conjecture, that this disguise was first laid aside in the smaller theatres.

Degradation of the Theatrical Profession.

But the principal change introduced by the Romans into the drama, and which continues to affect it in every country of Europe, respected the *status* or rank of the actors in society. We have seen that Athens, enthusiastic in her attachment to the fine arts, held no circumstances degrading which were connected with them. Eschylus and Sophocles were soldiers and statesmen, yet lost nothing in the opinion of their countrymen, by appearing on the public stage. Euripides, who was also a person of consequence, proved that "love esteems no office mean;" for he danced in a female disguise in his own drama, and that not as the Princess Nauticlea, but as one of her handmaidens, or, in modern phrase, as a *figurante*. The Grecians, therefore, attached no dishonour to the person of the actor, nor esteemed that he who contributed to giving the amusement of the theatre, was at all degraded beneath those who received it. It was otherwise in Rome. The contempt which the Romans entertained for players might be founded partly upon their confounding this elegant amusement with the games of the Circus and Amphitheatre, performed by gladiators and slaves, the meanest, in short, of mankind. Hence, to use the words of St Augustin, "the ancient Romans, accounting the art of stage-playing and the whole scene infamous, ordained that this sort of men should not only want the honour of other citizens, but also be disfranchised and thrust out of their tribe, by a legal and disgraceful censure, which the censors were to execute; because they would not suffer their vulgar sort of people, much less their senators, to be defamed, disgraced, or defiled with stage-players;" which act of theirs he styles "an excellent true Roman prudence, to be enumerated among the Romans' praises."

Accordingly, an edict of the prætor stigmatized as infamous all who appeared on the stage, either to speak or act; but it is remarkable that from this general proscription the Roman youth were excepted; and they continued to enact the *Fabulæ Atellanæ*, namely, the farces or drolleries of ancient Italian origin, without incurring any stigma. This exception seems to indicate, that the edict originated in the national pride of the Romans, and their contempt for Grecian literature, and for foreigners of every description. Under any other view it is impossible they should have preferred the actors in these coarse farces, who, by the bye, are supposed to have been the originals of no less persons than Harlequin and Punchinello, to those who possessed taste and talents sufficient to execute the masterly scenes borrowed from the Grecian drama.

Injustice, however, and we call that law unjust which devotes to general infamy any profession of which it nevertheless tolerates the practice, is usually inconsistent. Several individual play-actors in Rome rose to high public esteem, and to the enjoyment of great wealth. Roscius was the friend and companion of Piso and of Sylla, and, what was still more to his credit, of Cicero himself, who thus eulogises the scenic art, while commemorating the merit of his deceased friend: *Quis nostrum tam animo agresti ac duro fuit, ut Roscii morte nuper non commoveretur? qui quum esset senex mortuus, tamen, propter excellentem artem ac venustatem, videbatur omnino mori non debuisse.*

Paris, another Roman actor, reached a height of celebrity as distinguished as Roscius, and exercised, as many of his profession have since done, an arbitrary authority over the unfortunate dramatic authors. It is recorded by the satirist, that Statius the epic poet might have starved, had he not given up to this favourite of the public, upon his own terms doubtless, the manuscript of an unacted performance. Paris was put to death by Domitian out of jealousy.

If the actors rose to be persons of importance in Rome, the dramatic critics were no less so. They had formed a code of laws for the regulation of dramatic authors, to which the great names of Aristotle and Horace both contributed their authority. But these will be more properly treated of when we come to mention their adoption by the French stage.

Decay and disrepute of the Ancient Stage.

Having thus gone hastily through some account of the ancient stage, from its rise in Greece to its transportation to Rome, we have only to notice the circumstances under which it expired.

Christianity from its first origin was inimical to the institution of the theatre. The Fathers of the Church inveigh against the profaneness and immodesty of the theatre. In the treatise of Tertullian, *De Spectaculis*, he has written expressly upon the subject. The various authorities on this head have been collected and quoted by the enemies of the stage, from Prynne down to Collier. It ought, however, to be noticed, that their exprobation of the theatre is founded, first, upon its origin, as connected with heathen superstition: and secondly, on the beastly and abominable licence practised in the pantomimes, which, although they made no part of the regular drama, were presented nevertheless in the same place, and before the same audience. "We avoid your shows and games," says Tertullian, "because we doubt the warrant of their origin. They savour of superstition and idolatry, and we dislike the entertainment, as abhorring the heathen religion on which it is founded." In another place he observes, the temples were united to theatres, in order that superstition might patronize debauchery, and that they were dedicated to Bacchus and to Venus, the confederate deities of lust and intemperance.

It was not only the connection of the theatre with heathen superstition, that offended the primitive church; but also the profligacy of some of the entertainments which were exhibited. There cannot be much objected to the regular Roman dramas in this particular, since even Mr Collier allows them to be more decorous than the British stage of his own time; but, as we have already hinted, in the *Ludi Scenici*, the intrigues of the

gods and the heroes were represented upon the stage with the utmost grossness. These obscene and scandalous performances thus far coincided with the drama, that they were acted in the same theatres, and in honour of the same deities, and both were subjected to the same sweeping condemnation. They were not, however, absolutely or formally abolished, even when Christianity became the religion of the state. Tertullian and St Augustin both speak of the scenic representations of their own day, under the distinct characters of tragedy and comedy; and although condemned by the church, and abhorred by the more strict Christians, there is little doubt that the ancient theatre continued to exist, until it was buried under the ruins of the Roman Empire.

Modern Drama.

Dramatic Representations of the Middle Ages.

The same proneness to fictitious personification, which we have remarked as a propensity common to all countries, introduced, during the dark ages, a rude species of drama, into most of the nations of Europe. Like the first efforts of the ancients in that art, it had its foundation in religion; with this great difference, that as the rites of Bacchus before, and even after the improvements introduced by Thespis, were well enough suited to the worship of such a deity, the religious dramas, mysteries, or whatever other name they assumed, were often so unworthy of the Christian religion on which they were founded, that their being tolerated can be attributed only to the gross ignorance of the laity, and the cunning of the Catholic priesthood, who used them, with other idle and sometimes indecorous solemnities, as one means of amusing the people's minds, and detaining them in contented bondage to their spiritual superiors.

In the Empire of the East, religious exhibitions of a theatrical character appear to have been instituted about the year 990, by Theophylact, patriarch of Constantinople, with the intention (Warton surmises) of weaning the minds of the people from the Pagan revels, by substituting Christian spectacles, partaking of the same spirit of licence. His contemporaries give him little credit for his good intentions. "Theophylact," says Cedrenus, as translated by Warton, "introduced the practice, which prevails to this day, of scandalizing God and the memory of his saints, on the most splendid and popular festivals, by indecent and ridiculous songs, and enormous shoutings, even in the midst of those sacred hymns which we ought to offer to divine grace for the salvation of our souls. But he having collected a company of base fellows, and placing over them one Euthynicus surnamed Casnes, whom he also appointed the superintendent of his church, admitted into the sacred service diabolical dances, exclamations of ribaldry, and ballads borrowed from the streets and brothels."—The irregularities of the Greek clergy, who, on certain holidays, personated feigned characters, and entered even the choir in masquerade, are elsewhere mentioned. (Warton's *History of English Poetry*, Vol. II. p. 370.) These passages do not prove that actual mysteries or sacred dramas were enacted on such occasions; but probably the indecent revels alluded to bore the same relation to such representations, as the original rites of Bacchus to the more refined exhibitions of Thespis and Susarion.

There has been some dispute among theatrical antiquaries, in which country of Europe dramatic representations of a religious kind first appeared. The liberal and ingenious editor of the *Chester Mysteries* has well remarked (in his introduction to that curious and beautiful volume), that a difficulty must always attend the inquiry, from the doubts that exist, whether the earliest recorded performances of each country were merely pantomimes, or were accompanied with dialogue.

The practice of processions and pageants with music, in which characters, chiefly of sacred writ, were presented before the public, is so immediately connected with that of speaking exhibitions, that it is difficult to discriminate the one from the other.

We are tempted to look first to Italy; as it is natural that the tragic art should have revived in that country in which it was last exercised, and where traditions, and perhaps some faint traces, of its existence were still preserved.

"The first speaking sacred drama," says Mr Walker, "was *Della Passione di nostro Signor Gesù Christo*, by Giuliano Dati, bishop of San Leo, who flourished about the year 1445." (Walker's *Essay on the Revival of the Drama in Italy*, p. 6.) This elegant author does, indeed, show that Italian scholars, and particularly Mussato, the Paduan historian, had composed two Latin dramas upon something like the classical model, about the year 1300. Yet, although his play upon the tyranny and death of Ezzlino obtained him both reputation and honour, it does not appear to have been composed for the stage, but rather to have been a dramatic poem, since the progress of the piece is often interrupted by the poet speaking in his own person.

The French drama is traced by M. Le Grand as high as the thirteenth century; and he has produced one curious example of a pastoral, entitled, *Un Jeu*. He mentions also a farce, two devotional pieces, and two moralities, to each of which he ascribes the same title. It may be suspected, that these are only dialogues recited by the travelling minstrels and troubadours; such as Petrarch acknowledges having sometimes composed for the benefit of the strolling musicians. Such were probably the spectacles exhibited by Philip the Fair in 1313, on account of the honour of knighthood conferred on his children. Riccoboni, anxious for the honour of Italy, denies to these amusements the character of a legitimate drama; with what justice we have no information that can enable us to decide.

Amidst this uncertainty, it is not unpleasant to record the fair claim which Britain possesses to be one of the earliest, if not the very first nation in which dramatic representation seems to have been revived. The *Chester Mysteries*, called the *Whitsun Plays*, appear to have been performed during the mayoralty of John Arneway, who filled that office in Chester from 1268 to 1276. The very curious specimen of these mysteries, which has been of late printed for private distribution by Mr Markland of

the Temple, furnishes us with the banes or proclamation, containing the history and character of the pageants which it announces.

Reverende lordes and ladyes all,
That at this tyme here assembled bee,
By this messauge understande you shall,
That sometymes there was mayor of this citie,
Sir John Arnway, Knyghte, who most worthilye
Contented hymselfe to sett out an playe
The devise of one Done Rondali, moonke of Chester Abbey.

This moonke, moonke-like in scriptures well seene,
In storyes travelled with the best sorte;
In pagentes set fourth, apparently to all eyne,
The Olde and Newe Testament with livelye comforte;
Intermynglinge therewith, onely to make sporte,
Some things not warranted by any writt,
Which to gladd the hearers he woulde men to take yt.

This matter he abrevited into playes twenty-foure,
And every playe of the matter gave but a taste,
Leavinge for better learninge scircumstances to accomplishe,
For his proceedinges maye appeare to be in haste:
Yet all together unprofitable his labour he did not waste,
For at this daye, and ever, he deserveth the fame
Which all monkes deserves professinge that name.

This worthy Knihte Arnway, then mayor of this citie,
This order toke, as declare to you I shall,
That by twentye-fower occupations, artes, craftes, or misteries,
These pagentes shoulde be played after breeffe rehearsall;
For every pagente a cariage to be provyded withall,
In which sorte we purpose this Whitsontyde,
Our pageants into three partes to devyde.

I. Now you worshippfull TANNERS that of custome olde
The fall of Lucifer did set out,
Some writers awarrante your matter, therefore be boulde
Lustelye to playe the same to all the rowtte:
And yf any thereof stand in any doubte,
Your author his author hath, your shewe let bee,
Good speech, fyne players, with apparill comelye.
(*Chester Mysteries.*)

Such were the celebrated Mysteries of Chester. To Mr Markland's extracts from them is prefixed a curious dissertation upon their age and author. They were so highly popular, as to be ranked in the estimation of the vulgar with the ballads of Robin Hood; for a character in one of the old moralities is introduced as boasting

I can rhimes of Robin Hood, and Randal of Chester,
But of our Lord and our Lady I can nought at all.

The poetical value of these mysteries is never considerable, though they are to be found among the dramatic antiquities of all parts of Europe. It was, however, soon discovered that the purity of the Christian religion was inconsistent with these rude games, in which passages from Scripture were profanely and indecently mingled with human inventions of a very rude, and sometimes an indecorous character. To the Mysteries, therefore, succeeded the Moralities, a species of dramatic exercise, which involved more art and ingenuity, and was besides much more proper for a public amusement, than the imitations or rather parodies of Sacred History, which had hitherto entertained the public.

Moralities. These Moralities bear some analogy to the old or original comedy of the ancients. They were often founded upon allegorical subjects, and almost always bore a close and poignant allusion to the incidents of the day. Public reformation was their avowed object, and, of course, satire was frequently the implement which they employed. Dr Percy, however, remarks that they were of two characters, serious and ludicrous; the one approaching to the tragedy, the other to the comedy of classical times; so that they brought taste as it were to the threshold of the real drama. The difference betwixt the Catholic and reformed religion was fiercely disputed in some of these dramas; and in Scotland, in particular, a mortal blow was aimed at the superstitions of the Roman Church, by the celebrated Sir David Lindsay, in a play or morality acted in 1539, and entitled *The Satire of the Three Estates.* The objects of this drama were entirely political, although it is mixed with some comic scenes, and introduced by an interlude, in coarseness altogether unmatched. The spirit of Aristophanes, in all its good and evil, seems to have actuated the Scottish king-at-arms. It is a singular proof of the liberty allowed to such representations at the period, that James V. and his queen repeatedly witnessed a piece, in which the corruptions of the existing government and religion were treated with such satirical severity. The play, as acted, seems to have differed in some respects from the state in which it exists in manuscript.

In a letter to the Lord Privy Seal of England, dated 26th January 1540, SIR WILLIAM EURE (ENVOY FROM HENRY VIII.) gives the following account of the play, as it had then been performed "in the feast of Ephipanie at Lightgowe, before the king, queene, and the whole counsaile, spirituall and temporall.—In the firste entres come in SOLACE (whose parte was but to make mery, sing ballets with his fellowes, and drinke at the interluydes of the play), whoe showed firste to all the audience the play to be played. Next come in a king, who passed to his throne, having nae speche to thende of the play, and then to ratify and approve, as in Parliament, all things done by the rest of the players, which represented THE THREE ESTATES. With hym came his cortiers, PLACEBO, PICTHANK, and FLATTERYE, and sic alike gard; one swering he was the lustiest, starkeste, best proportionit, and most valyeant man that ever was; ane other swere he was the beste with long-bowe, crosse-bowe, and culverin, and so fourth. Thairafter there come a man armed in harness, with a swerde drawn in his hande, a BUSHOP, a BURGES-MAN, and EXPERIENCE, clede like a DOCTOR; who set them all down on the deis under the KING. After them come a POOR MAN, who did go up and down the scaffolde, making a hevie complainte that he was hereyet, throw the courtiers taking his fewe in one place, and his tackes in another; wherthrough he had sceyled his house, his wyfe and childrene beggyng thair brede, and so of many thousands in Scotland; saying thair was no remedy to be gotten, as he was neither acquainted with controller nor treasurer. And then he looked to the King, and said he was not King in Scotland, for there was ane other King in Scotland that hanged JOHNE ARMSTRANG, with his fellowes, SYM THE LAIRD, and mony other mae; but he had

lefte ane thing undone. Then he made a long narracione of the oppression of the poor, by the taking of the corse-presaunte beists, and of the herrying of poor men by the consistorye lawe, and of many other abusions of the SPIRITUALITIE and Church. Then the BUSHOP raise and rebuked him. Then the MAN OF ARMES alledged the contraire, and commanded the poor man to go on. The poor man proceeds with a long list of the bishop's evil practices, the vices of cloisters, &c. This proved by EXPERIENCE, who, from a New Testament, shows the office of a bushop. The MAN OF ARMES and the BURGES approve of all that was said against the clergy, and alledge the expediency of a reform, with the consent of Parliament. The BUSHOP dissents. The MAN OF ARMES and the BURGES said they were two, and he but one, wherefore their voice should have most effect. Thereafter the King, in the play, ratified, approved, and confirmed all that was rehersed."

The other nations of Europe, as well as England, had their mysteries and moralities. In France, Boileau, following Menestrier, imputes the introduction of these spectacles to travelling bands of pilgrims.

> Chez nos devots ayeux, le theatre abhorré
> Fut long-temps dans la France un plaisir ignoré ;
> Des pelerins dit-on, une troupe grossiere
> En public a Paris y monta la premiere ;
> Et sottement zeéle en sa simplicité
> Joüa les saints, la Vierge, et Dieu par pieté.
> *L'Art Poetique*, Chant. III.

In Spain the *Autos Sacramentales*, which are analogous to the mysteries of the middle ages, are still presented without shocking a nation whose zeal is stronger than their taste; and, it is believed, such rude and wild plays, founded on scripture, are also occasionally acted in Flanders. In the *History of the Council of Constance*, we find that mysteries were introduced into Germany by the English, about 1417, and were first performed to welcome the Emperor Sigismund, on his return from England; and, from the choice of the subjects, we should almost suppose, that they had transferred to that country the *Chester Mysteries* themselves. "Les Anglois," says the historian, "se signalerent entre les autres par un spectacle nouveau ou au moins inusité jusques alors en Allemagne. Ce fut une comedie sacrée que les Eveques Anglois firent représenter devant l'Empereur, le Dimanche 31 de Jarvier, sur la naissance du Sauveur, sur l'arrivée des Mages et sur la Massacre des Innocens." (*Hist. du Concile des Constance*, par L'Enfant, lib. v.) The character of these rude dramatic essays renders them rather subjects for the antiquary, than a part of a history of the regular dramatic art.

[...]n Plays.

We may also pass over, with brief notice, the Latin plays which, upon the revival of letters, many of the learned composed, in express imitation of the ancient Grecian and Latin productions. We have mentioned those of Mussato, who was followed by the more celebrated Cararo, in the path which he had opened to fame. In other countries the same example was followed. These learned prolusions, however, were only addressed to persons of letters, then a very circumscribed circle, and, when acted at all, were presented at universities or courts on solemn public occasions. They form no step in the history of the drama, unless that, by familiarizing the learned with the form and rules of the ancient classical drama, they gradually paved the way for the adoption of the same regulations into the revived vernacular drama, and formed a division amongst the theatres of modern Europe, which has never yet been reconciled.

Historical Plays.

While the learned laboured to revive the classical drama in all its purity, the public at large, to which the treasures of the learned languages were as a fountain sealed, became addicted to a species of representation which properly neither fell under the denomination of comedy or tragedy, but was named History or Historical Drama. Charles Verardo, who, about 1492, composed a drama of this sort, in Latin, upon the expulsion of the Moors from Granada, claims, for this production, a total emancipation from the rules of dramatic criticism.

> *Requirat autem nullus hic comedæ,*
> *Leges ut observantur, aut tragediæ,*
> *Agenda nempe est* HISTORIA *non fabula.*

"Let none expect that in this piece the rules of comedy or of tragedy should be observed; we mean to act a history, not a fable." From this expression it would seem, that, in a historical drama, the author did not think himself entitled to compress or alter the incidents as when the plot was fabulous, but was bound, to a certain extent, to conform to the actual course of events. In these histories, the poet embraced often the life and death of a monarch, or some other period of history, containing several years of actual time, which, nevertheless, were made to pass before the eyes of the audience during the two or three hours usually allotted for the action of a play. It is not to be supposed that, with so fair a field open before them, and the applause of the audience for their reward, the authors of these histories should long have confined themselves to the matter of fact contained in records. They speedily innovated or added to their dramatic chronicles without regard to the real history. To those who plead for stage-plays, that they elucidate and explain many dark and obscure histories, and fix the facts firmly in the minds of the audience, of which they had otherwise but an imperfect apprehension, the stern Prynne replies with great scorn, "that play-poets do not explain but sophisticate and deform good histories, with many false varnishes and playhouse fooleries;" and that "the histories are more accurately to be learned in the original authors who record them, than in derivative playhouse pamphlets, which corrupt them." (Prynne's *Histrio-Mastix*, p. 940.)

The dramatic chronicles, therefore, were a field in which the genius of the poet laboured to supply by character, sentiment, and incident, the meagre detail of the historian. They became so popular in England, that, during the short interval betwixt the revival of the stage and the appearance of Shakespeare, the most part of the English monarchs had lived and died upon the stage; and, it is well-known, that al-

most all his historical plays were new written by him, upon the plan of old dramatic chronicles which already existed.

But the miscellaneous audience which crowded to the vernacular theatre at its revival in Europe, were of that rank and intellect which is apt to become tired of a serious subject, and to demand that a lamentable tragedy should be intermingled with very pleasant mirth. The poets, obliged to cater for all tastes, seldom failed to insert the humours of some comic character, that the low or grotesque scenes in which he was engaged, might serve as a relief to the graver passages of the drama, and gratify the taste of those spectators who, like Christofero Sly, tired until the fool came on the stage again. Hence Sir Philip Sidney's censure on these dramatists, " how all their plays be neither right tragedies nor right comedies, mingling kings with clowns; not because the matter so carrieth it, but to thrust in the clown, by head and shoulders, to play a part in magestical matters, with neither decency nor discretion, so that neither the admiration and commiseration, nor the right sportfulness, is by their mongrel tragi-comedy attained." (*Defence of Poesie*. Sidney's *Arcadia*, edit. 1627, p. 563.) " If we mark them well," he concludes, " funerals and hornpipes seldom match daintily together."

Romantic Drama.

The historical plays led naturally into another class, which may be called Romantic Dramas, founded upon popular poems or fictitious narratives, as the former were on real history. Some of these were borrowed from foreign nations, ready dramatized to the hand of the borrower; others were founded on the plots which occurred in the almost innumerable novels and romances which we had made our own by translation. " I may boldly say it," says Gosson, a recreant play-wright who attacked his former profession, " because I have seen it, that the *Palace of Pleasure*, the *Golden Asse*, the *Ethiopian History*, *Amadis of Fraunce*, the *Round Table*, *Bawdie Comedies in Latin*, *French*, *Italian*, *and Spanish*, have been thoroughly ransacked to furnish the playhouse in London." But it was not to be supposed that the authors would confine themselves to stricter rules in pieces founded upon Italian and Spanish novels, or upon romances of chivalry, than they had acted upon in the histories. Every circumstance which tended to loosen the reins of theatrical discipline, in the one case, existed in the other; and, accordingly, comedies of intrigue, and tragedies of action and show, everywhere superseded, at least in popular estimation, the severe and simple model of the classical drama.

It happened that in England and Spain, in particular, that the species of composition which was most independent of critical regulation was supported by the most brilliant display of genius. Lopez de Vega and Calderon rushed on the stage with their hasty and high-coloured, but glowing productions, fresh from the mint of imagination, and scorning that the cold art of criticism should weigh them in her balance. The taste of the Spaniards has been proverbially inclined to the wild, the romantic, and the chivalrous; and the audience of their bards would not have parted with one striking scene, however inartificially introduced, to have gained for their favourites the praise of Aristotle and all his commentators. Lopez de Vega himself was not ignorant of critical rules; but he pleads the taste of his countrymen as an apology for neglecting those restrictions which he had observed in his earlier studies.

" Yet true it is I too have written plays,
The wiser few, who judge with skill, might praise;
But when I see how show and nonsense draws
The crowds, and, more than all, the fair's applause;
Who still are forward with indulgent rage
To sanction every monster of the stage;
I, doom'd to write the public taste to hit,
Resume the barbarous dress 'twas vain to quit;
I lock up every rule before I write,
Plautus and Terence banish from my sight,
Lest rage should teach these injured wits to join
And their dumb books cry shame on works like mine.
To vulgar standards, then, I frame my play,
Writing at ease, for, since the public pay,
'Tis just, methinks, we by their compass steer,
And write the nonsense that they love to hear."

Lord Holland's *Life of Lope de Vega*, p. 103.

The Spanish comedies of intrigue also went astray, as far as their romantic tragedies, from the classical path. In fact, these new representations were infinitely more captivating from their vivacity, novelty, and above all, from their reflecting the actual spirit of the time, and holding the mirror up to nature, than the cold imitations which the learned wrote in emulation of the classic drama. The one class are existing and living pictures of the times in which the authors lived; the others, the cold resurrection of the lifeless corpses which had long slumbered in the tomb of antiquity. The spirit of chivalry, which so long lingered in Spain, breathes through the wild and often extravagant genius of her poets. The hero is brave and loyal, and true to his mistress;

A knight of love who never broke a vow.

Lovers of this description, in whose minds the sexual passion is sublimated into high and romantic feeling, make a noble contrast with the coarse and licentious Greek or Roman, whose passion turns only on the difficulty of purchasing his mistress's person, but who never conceives the slightest apprehension concerning the state of her affections.

That the crowd might have their loud laugh, a *grazioso* or clown, usually a servant of the hero, is in the Spanish drama uniformly introduced to make sport. Like Kemp or Tarletun, famous in the clown's part before the time of Shakespeare, this personage was permitted to fill up his part with extemporary jesting, not only on the performers, but with the audience. This irregularity, with others, seems to have been borrowed by the English stage from that of Spain, and is the licence which Hamlet condemns in his instructions to the players: " And let those that be your clowns speak no more than is set down for them; for there be of them that will themselves laugh, to set on some quantity of barren spectators to laugh too, though, in the meantime, some necessary question of the play be then to be considered;—that's villainous, and shows a most pitiful ambition in the fool that uses it."

The bald simplicity of the ancient plots was, in like manner, contrasted to disadvantage with the intricacies, involutions, suspense, and bustle of Spanish

intrigue upon the stage. Hence the boast of one of their poets, thus translated by Lord Holland:

> "Invention, interest, sprightly turns in plays,
> Say what they will, are Spain's peculiar praise;
> Her's are the plots which strict attention seize,
> Full of intrigue, and yet disclosed with ease.
> Hence acts and scenes her fertile stage affords,
> Unknown, unrivall'd, on the foreign boards."
> *Life of Lope de Vega*, p. 106.

While we admire the richness of fancy displayed in the Spanish pieces, it is impossible, in an age of refinement, to avoid being shocked by their wilful and extravagant neglect of every thing which can add probability to the action of their drama. But the apology for this licence is well pleaded by Lord Holland.

"Without dwelling on the expulsion of the chorus (a most unnatural and inconvenient machine), the moderns, by admitting a complication of plot, have introduced a greater variety of incidents and character. The province of invention is enlarged; new passions, or at least new forms of the same passions, are brought within the scope of dramatic poetry. Fresh sources of interest are opened, and additional powers of imagination called into activity. Can we then deny what extends its jurisdiction, and enhances its interest, to be an improvement in an art whose professed object is to stir the passions by the imitation of human actions? In saying this I do not mean to justify the breach of decorum, the neglect of probability, the anachronisms and other extravagancies of the founders of the modern theatre. Because the first disciples of the school were not models of perfection, it does not follow that the fundamental maxims were defective. The rudeness of their workmanship is no proof of the inferiority of the material; nor does the want of skill deprive them of the merit of having discovered the mine. The faults objected to them form no necessary part of the system they introduced. Their followers in every country have either completely corrected or gradually reformed such abuses. Those who bow not implicitly to the authority of Aristotle, yet avoid such violent outrages as are common in our early plays. And those who pique themselves on the strict observance of his laws, betray, in the conduct, the sentiments, the characters, and the dialogue of their pieces (especially of their comedies) more resemblance to the modern than the ancient theatre; their code may be Grecian, but their manners, in spite of themselves, are Spanish, English, or French. They may renounce their pedigree, and even change their dress, but they cannot divest their features of a certain family-likeness to their poetical progenitors."

In France the irregularities of the revived drama were of a lower complexion; for, until her stage was refined by Corneille, and brought under its present strict *regime*, it was adorned by but little talent; a circumstance which, amongst others, may account for the ease with which she subjected herself to critical rules, and assumed the yoke of Aristotle. Until she assumed the Grecian forms and restrictions, there is but little interesting in the history of her stage.

England adopted the historical and romantic drama with ardour, and in a state scarce more limited by rules than that of Spain herself. Her writers seem early to have ransacked Spanish literature; for the union of the countries during the short reign of Mary, nay even their wars under Elizabeth and Philip, made them acquainted with each other. The Spaniards had the start in the revival of the drama. *Ferrex and Perrex*, our earliest tragedy, was first presented in 1561; and *Gammer Gurton's Needle*, our first comedy, in 1575; whereas Lopez de Vega (who was not by any means the earliest Spanish dramatist) died in 1562, leaving the stage stocked with his innumerable productions, to which his contemporaries had not failed to add their share. Thus, so soon as the stage of Britain was so far advanced as to be in a capacity of borrowing, that of Spain offered a fund to which her authors could have recourse; and, in fact, the Spanish drama continued to be a mine in which the British poets collected materials, often without acknowledgment, during all the earlier part of her dramatic history. From this source, as well as from the partialities of the audience, arose that early attempt at show and spectacle, at combats and marvellous incidents, which, though with very poor means of representation, our early dramatic poets loved to produce at the Bull or the Fortune playhouses. The extravagance of their plots, and the poor efforts by which our early dramatists endeavoured to represent show and procession, did not escape the censure of Sir Philip Sidney, who, leaning to the critical reformation which was already taking place in Italy, would gladly have seen our stage reduced to a more classical model.

"It is faultie," says that gallant knight, "both in place and time, the two necessarie companions of all corporall actions. For the stage should alway present but one place; and the uttermost time presupposed in it should bee both by *Aristotle's* precept, and common reason, but one day; there are both many dayes and many places inartificially imagined. But if it be so in *Gorboduke*, how much more in all the rest? where you shall have *Asia* of the one side, and *Affricke* of the other, and so many other under kingdomes, that the plair when he comes in, must ever begin with telling where hee is, or else the tale will not be conceived. Now shall you have three ladies walke to gather flowers, and then wee must beleeve the stage to be a garden. By and by wee heare newes of shipwracke in the same place, then wee are to blame if we accept it not for a rocke. Upon the backe of that comes out a hideous monster with fire and smoke, and then the miserable beholders are bound to take it for a cave; while, in the mean time, two armies flie in, represented with some swordes and bucklers, and then what hard heart will not receive it for a pitched field? Now of time they are much more liberall; for ordinarie it is, that two young princes fall in love. After many traverses shee is got with childe, delivered of a faire boy; he is lost, groweth a man, falleth in love, and is readie to get another childe, and all this in two houres space; which how absurd it is in sense, even sense may imagine, and art hath taught, and all ancient examples justified, and at this day the ordinary players in *Italy* will not err in."

Drama.

Italian Tragedy.

Italy, referred to by Sir Philip Sidney, as the cradle of the reformed drama, had had her own age of liberty and confusion; her mysteries, her moralities, her historical, and her romantic dramas. But the taste for the ancient and classical stage was still rooted in the country where it had flourished, and Trissino is acknowledged as the father of the regular drama. The *Sophonisba* of this learned prelate is praised by Voltaire as the first regular tragedy which Europe had seen after so many ages of barbarism. Pope has added his tribute.

When learning, after the long Gothic night,
Fair o'er the western world renewed its light,
With arts arising, Sophonisba rose,
The tragic muse returning wept her woes;
With her the Italian scene first learned to glow,
And the first tears for her were taught to flow.

This tragedy was represented at Rome in the year 1515. The Greek model is severely observed, and the author has encumbered his scene with a chorus. It has some poetic beauties, and is well calculated to recommend the new or rather revived system on which it was written. *La Rosmonda* of Rucelleri was written about the same time with *Sophonisba;* and, after these pieces, tragi-comedies, histories, and romantic dramas, were discarded, and succeeded by tragedies upon a regular classical model; written in verse, having five acts, and generally a chorus.

Notwithstanding their rigorous attention to the ancient model, the modern tragic poets of Italy have not been very successful in arresting the attention of their countrymen. They are praised rather than followed; and the stern and unbending composition of Alfieri, while it has given a tone of rude and stoical dignity to his dramas, has failed in rendering them attractive. They frequently please in the closet; but the audience of modern days requires to be kept awake by something more active, more bustling, more deeply interesting, than the lessons of the schools; and a poet of high fancy has written in some measure in vain, because he has mistaken the spirit of his age. The tragic actors also, whatever excellence they may attain to in their art, do not attract the same consideration, attention, and respect, as in France or England; and they who are the direct authors of a pleasure so nearly connected with our noblest and best feelings, occupy a rank subordinate to the performers at the opera.

Opera.

It is only as a modification of the drama, that we here propose to touch upon that entertainment of Italian growth, but known by importation in every civilized kingdom of Europe. These kingdoms have often rivalled each other in the rewards held forth to musical performers, and encouraged their merit by a degree of profusion, which has had the effect of rendering the professors petulant, capricious, and unmanageable. Their high emoluments are not granted, or their caprices submitted to, without a degree of pleasure in some degree corresponding to the expence and the sufferance; and it is in vain for the admirers of the legitimate drama to pretend that such is not obtained. Voltaire has with more justice confessed, that probably the best imitation of the ancient stage was to be found in the Italian tragic opera. The recitative resembled the musical declamation of the Athenians, and the choruses, which are frequently introduced, when properly combined with the subject, approach to those of the Greeks, as forming a contrast, by the airs which they execute, to the recitative, or modulated dialogue of the scene. Voltaire instances the tragic operas of Metastasio in particular, as approaching in beauty of diction, and truth of sentiment, near to the ancient simplicity; and finds an apology even for the detached airs (so fatal to probability), in the beauty of the poetry and the perfection of the music. And although, as a critic and man of cultivated taste, this author prefers the regular, noble, and severe beauties of the classic stage, to the effeminate and meretricious charms of the opera, still he concludes, that, with all its defects, the sort of enchantment which results from the brilliant intermixture of scenery, chorus, dancing, music, dress, and decoration, subjects even the genius of criticism; and that the most sublime tragedy, and most artful comedy, will not be so frequently revisited by the same individual as an indifferent opera. We may add the experience of London to the testimony of this great critic; and, indeed, were it possible that actors could frequently be procured, possessed of the powers of action and of voice, which were united in Grassini, it would be impossible to deny to the opera the praise of being an amusement as exquisite in point of taste, as fascinating from show and music. But as the musical parts of the entertainment are predominant, every thing else has been too often sacrificed to the caprice of a composer, wholly ignorant in every art save his own; and the mean and paltry dialogue, which is used as a vehicle for the music, is become proverbial to express nonsense and inanity.

Italian Comedy.

The Italian comedy, as well as their tragedy, boasts its regular descent from classical times. Like the comedy of Menander, it introduces *dramatis personæ,* whose characters are never varied, and some of whom are supposed to be directly descended from the ancient *Mimi* of the *Atellanian* fables. Such an origin is claimed for the celebrated Harlequin, and for the no less renowned Puncinello, our English Punch, both of whom retain the character of jesters, cowards, wags, and buffoons, proper to the *Sannio* of the Romans. It is believed of these worthies, that they existed before the time of Plautus, and continued to play their frolics during the middle ages, when the legitimate drama was unknown. For the former fact, sculpture, as well as tradition, is appealed to by Italian antiquaries, who have discovered the representation of these grotesque characters upon the Etruscan vases. In support of the latter averment, the grave authority of Saint Thomas Aquinas is appealed to, who, we rejoice to find, thought Harlequin and Punch no unlawful company in fitting time and place. "*Ludus,*" says that eminent person, with more consideration for human infirmity than some saints of our own day, "*est necessarius ad conversationem vitæ humanæ: ad omnia autem quæ sunt utilia conversationi humanæ, deputari possunt aliqua officia licita: et ideò etiam officium histrionum quod ordinatur ad solatium hominibus exhibendum, non est secundum se illicitum, nec sunt histriones in statu peccati, dummodo moderatè ludo utantur; id est, non utendo*

Drama.

aliquibus illicitis verbis vel factis, ad ludum, et non adhibendo ludum negotiis et temporibus indebitis, unde illi qui moderate eis subveniunt, non peccant, sed juste faciunt mercedem ministerii eorum eis tribuendo. Et licit D. August. super Joan. *dicit quod donare res suas histrionibus, vitium est immane, hoc intelligi debet de illis qui dant histrionibus qui in ludo utuntur illicitis, vel de illis qui superflue sua in tales consumunt, non de illis histrionibus qui moderate ludo utuntur.*"

Saint Anthony gives his sanction to Saint Thomas on this point: "*Histrionatus ars quia deservit humanæ recreationi quæ necessaria est vitæ hominis secundum D. Thoman, de se non est illicita et de illa arte vivere non est prohibitum.*" (S. Antonius in 3 part. *suæ Summæ*, tit. iii. cap. 4.) Saint Anthony, indeed, adds the reasonable restriction, that no clergyman should play Harlequin, and that Punch should not exhibit in the church.

Under this venerable authority these *Mimi* went on and flourished. Other characters enlarged their little drama. The personages appeared in masks. "Each of these," says Mr Walker, "was originally intended as a kind of characteristic representation of some particular Italian district or town. Thus *Pantalone* was a Venetian merchant; *Dottore* a Bolognese physician; *Spaviento* a Neapolitan braggadocio; *Pullicinella* a wag of Apulia; *Giangurgolo* and *Coviello* two clowns of Calabria; *Gelsomino* a Roman beau; *Beltrame* a Milanese simpleton; *Brighella* a Ferarese pimp; and *Arlecchino* a blundering servant of Bergamo. Each of these personages was clad in a peculiar dress; each had his peculiar mask; and each spoke the dialect of the place he represented. Besides these, and a few other such personages, of which at least four were introduced in each play, there were the *Amoroso's* or *Innamorato's*; that is, some men and women who acted serious parts, with Smeraldina, Colombina, Spilletta, and other females, who played the parts of servetta's or waiting-maids. All these spoke Tuscan or Roman, and wore no masks." (*Essay on the Revival of the Drama in Italy*, p. 249.)

The pieces acted by this class of actors were called *Commedia dell' arte*, and were congenial to the taste of the Italians, with whom gesticulation and buffoonery are natural attributes. Their drama was of the most simple kind. Each of the actors was already possessed of his dramatic character, which was as inalienable as his dress, and was master of the dialect he was to use, and had his imagination and memory stored with all the characteristic jests, or *lazzi* as they were termed, peculiar to the personage he represented. All that the author had to do was to invent the skeleton of a plot, which should bring his characters into dramatic situation with respect to each other. The dialogue suited to the occasion was invented by the players, just as ours invest their parts with the proper gestures and actions. This skeleton had the name of *scenario*, and was filled up by the performers, either impromptu, or in consequence of previous arrangement and premeditation. This species of comedy was extremely popular, especially among the lower class of spectators. It was often adopted as an amusement in good society, and by men of genius; and Flamineo de la Scala has left about fifty such *scenarios* adapted for representation. The fashion even found its way into England, and probably the part of Master Punch, who first appeared in the character of the *Vice* of the English morality, was trusted to the improvisatory talents of the actor. Mr D'Israeli, a curious as well as elegant investigator of ancient literature, has shown, that at least one scheme of a *Commedia dell' arte* has been preserved to us. It is published in the *Variorum* edition of Shakespeare, but remains unexplained by the commentators. Such comedies, it is evident, could require no higher merit in the composer than the imagining and sketching a few comic situations; the dialogue and diction was all entrusted to the players.

The Italians, however, became early possessed of a regular comedy, which engrossed the admiration of the more cultivated classes of society. Bibbiena's comedy, entitled *La Calandra,* is composed in imitation of the dramas of Terence and Plautus. It was first acted in 1490. *La Calandra* is remarkable not only for being the first Italian comedy, but also for the perfection of scenic decoration with which it was accompanied in the representation. It was followed by the productions of Ariosto and Trissino and other authors in the same line. But it appears from the efforts used to support this style of drama, that it did not take kindly root in the soil, and lacked that popularity which alone can nurse it freely. Various societies were formed under the whimsical titles of *Gli Intronati, Gli Insensati,* and so forth, for the express purpose of bringing forward the regular drama; exertions which would certainly have been unnecessary, had it received that support and encouragement which arises from general popularity.

Goldoni, in a later age, at once indulged his own fanciful genius and his natural indolence by renouncing the classical rules, and endeavouring to throw into the old and native Italian *Mascherata* the variety and attributes of the proper comedy. He adopted Harlequin and the rest of his merry troop in the characters which they held, and endeavoured to enlist them in the more regular service of the drama; just as free corps and partizans are sometimes new modelled into battalions of the line. This ingenious and lively writer retained all the licence of the *Commedia dell' arte*, and all the immunities which it claimed from regular and classical rules; but instead of trusting to the extempore jests and grotesque wit of the persons whom he introduced, he engaged them in dialogues, as well as plots, of his own invention, which often display much humour and even pathos. It required, however, the richness of a fancy like Goldoni's to extract novelty and interest from a dramatic system in which so many of the actors held a fixed and prescriptive character, hardly admitting of being varied. Accordingly, we do not find that the Italian stage is at present in a more flourishing condition than that of other modern nations.

French Drama.

The revival of the regular drama in France was attended with important consequences, owing to the nature of her government, the general use of her language throughout Europe, and the influence which, from her situation, she must necessarily hold over other nations. It is the boast of Paris that the regular

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classical drama, banished from every other stage, found a safe and honourable refuge on her own. Yet France has reluctantly confessed that she also had her hour of barbarism. Her earlier drama was borrowed, like that of other countries, from Spain, who, during the whole of the sixteenth and great part of the seventeenth century, held such a formidable predominance in the European republic. While the classical stage was reviving in Italy, and the historical and romantic drama was flourishing in Spain, France was torn to pieces by civil discord. The first French tragedy composed upon a regular plan was that of *Mairet*, imitated from the *Sophonisba* of Trissino; and Riccoboni boasts with justice, that whoever shall compare the Italian tragedy of the sixteenth century with that of the French of the same period, will find the latter extravagant and irregular, and the former already possessed of gravity, dignity, and regularity. The French, like the English, date the excellence of their stage from one great author; and the illustrious name of Pierre Corneille affords to their dramatic history the mighty landmark which Shakespeare gives to our own.

Cardinal Richelieu, who had succeeded in establishing upon a broad basis the absolute power of the French monarch, was not insensible to the graces and ornaments which the throne derived from being surrounded by the muses. He was himself fond of poetry, and even a competitor for the honours of the buskin. He placed himself at the head of five dramatic writers, to whom, on that account, the public gave the title of *Les cinq Auteurs*. All these are deservedly forgotten excepting Corneille, of whose successful talent the cardinal had the meanness to evince no ordinary degree of jealousy. The malevolence of that minister was carried so far, that he employed the French Academy, whose complaisance must be recorded to their shame, to criticise severely the *Cid*, the first, and perhaps the finest of Corneille's tragedies. Scuderie, a favourite of the Cardinal, buoyed by Richelieu's favour, was able for some time to balance Corneille in the opinion of the public; but his name is now scarcely known by any other circumstance than his imprudent and audacious rivalry. This great man was not only surrounded by the worst possible models, but unfortunately the authors of these models were also favourites of the public, and of the all-powerful cardinal; yet Corneille vanquished the taste of his age, the competition of his rivals, and the envy of Richelieu.

Corneille, like his predecessors, and like Routrou in particular, borrowed liberally from the Spanish theatre; but his own taste, regulated probably upon his situation, dictated an adherence to the classical model. The French stage arose, it must be remembered, under the protection of an absolute monarch, for whose amusement the poet laboured, and in whose presence the drama was performed. It followed, as a natural consequence, that a more strict etiquette was exacted upon the scene than had hitherto been supposed applicable to a merely popular amusement. A departure from regularity in tragedy was no longer a bold flight. A violation of decorum in comedy was no longer a broad jest. When the audience was dignified by the presence of the monarch, the former became an impertinence, and the latter a gross and indecent insult. The muse of comedy was therefore bound over for her good behaviour; and even her grave sister was laid under such rules and restrictions as should insure the decorum and dignity of her scene.

French Writers enforce the *Unities*.

It was at this period that those classical fetters which are framed on the three unities were fashioned into form, and imposed on the French drama. These are acknowledged by Corneille, in his *Essay upon Dramatic Poetry*, in the following short but emphatic sentence: "*Il faut observer les unités d'action, de lieu, et de jour: personne n'en doute.*" The rule, as thus emphatically admitted by the fiery Corneille, was equally binding upon the elegant Racine, and has fettered the French stage until the present day. "La Motte," says Voltaire, "a man of wit and talent, but attached to paradoxes, has written in our time against the doctrine of the Unities, but that literary heresy had no success."

Upon these rules, adopted by the very first writer of eminence for the French stage, and subscribed to by all succeeding dramatists, depends the principal and long-disputed difference betwixt the drama of France and those countries in which her laws of taste have been received; and the stages of Spain, England, and modern Germany, where those critical maxims have been controverted. In other words, the unities proper to the classical drama have been found inapplicable to plays of a historical or romantic plan. It is, therefore, necessary to examine with accuracy the essence and effect of those laws so often disputed with more obstinacy than liberality.

Examination of this Doctrine.

The arbitrary forms to which the French thus subjected their theatre are, in their general purport, founded on good and sound rules of the critical art. But, considered judaically and literally, the interpretation put upon those unities by the French critics must necessarily lay the dramatic author under restraints equally severe and unnecessary, without affording any corresponding addition to the value of his work. The pedantry by which they are enforced reminds one of the extreme, minute, rigorous, and punctilious discipline to which some regiments have been subjected by a pedantic commanding officer, which seldom fails to lower the spirit, and destroy the temper of the soldier, without being of the slightest service to him in the moment of danger or the day of battle.

The first dramatic unity is that of Action, and, rightly understood, it is by far the most important. A whole, says Aristotle, is that which has a beginning, middle, and end. In short, one strong concentrated interest upon which all subordinate incidents depend, and to which they contribute, must pervade the piece. It must open with the commencement of the play, evolve itself, and be progressive with its progress,—must be perpetually in sight and never stationary, until at length it arrives at a catastrophe, by which it is ended and extinguished. In this rule, abstractedly considered, there is nothing but what is consistent with good sense and sound criticism. The period allowed for dramatic representation is not long, and will not admit of the episodical ornaments which may be happily

introduced into epic poetry. And as the restlessness or impatience of a theatrical audience is always one of its marked characteristics, it has been observed, that neither the most animated description, nor the most beautiful poetry, can ever reconcile the spectators to those inartificial scenes in which the plot or action of the piece stands still, that the performers may say fine things. The introduction of an interest, separate and distinct from the main action of the play, has a still worse effect; it diminishes the effect of the whole, and divides the attention of the audience; as a pack of hounds, when in full pursuit, are impeded and puzzled by starting a fresh object of chase.

Yet even this rule must be liberally considered, if we would allow dramatic authors that fair room and exercise for their genius, which gives rise to the noblest displays of genius in the art. Modern dramatists are no longer, it must be remembered, limited to the simple and surer uniformity of the ancient drama, which fixed on one single event as its object,—made it the subject of the moral reflections of the chorus,—managed it by the intervention of three or at most five persons, and consequently presented a picture so limited in size and subject, that there was no difficulty in avoiding the intermixture of a foreign interest. The modern taste has opened the stage to a wider range of topics, which are, at the same time, more complicated in detail, depending on the agency of a variety of performers, and on the result of a succession of events. Such dramas have indeed an unity of action peculiar to themselves, which should predominate over and absorb every other. But although, like the oak, it should predominate over all the neighbouring underwood, its dignity is not injured by the presence and vicinity of that which it overshadows. On the contrary, a succession of events tending to the same end, if they do not divert the attention from the principal interest, cannot fail, by their variety and succession, to keep it fixed upon the business of the scene.

To take an example. In the tragedy of Macbeth a chain of varied and important events are introduced, any one link of which might be hammered out into a drama on the severe and simple model of the drama of ancient Greece. There is the murder of Duncan,—that of Banquo,—and the dethronement and death of the tyrant; all which are events complete of themselves, independent of each other, and yet included within one tragedy of five acts. But, nevertheless, this is never felt as a deficiency in the performance. It is to the character of Macbeth, to his ambition, guilt, remorse, and final punishment, that the mind attaches itself during the whole play; and thus the succession of various incidents unconnected excepting by the relation they bear to the principal personage, far from distracting the attention of the audience, continues to sharpen and irritate curiosity till the curtain drops over the fallen tyrant. This is not, indeed, an unity of action according to the rule of Aristotle, or the observance of the French theatre. But, in a higher point of view, it has all the advantage which could possibly be derived from the severest adherence to the precept of Aristotle, with this additional merit, that the interest never stagnates in declamation, or is suspended by unnecessary dialogue.

It would in fact be easy to show, that the unity of action, in its strict sense, may frequently be an unnatural as well as a cumbrous restraint on the genius of the poet. In the course of nature, an insulated action seldom exists of a nature proper to transfer to the stage. If, indeed, the play is founded on some single mythological fable, or if the scene is laid in some early stage of society, when man as yet remained separated from his kind, and connected only with his petty tribe or family, the subject of a plot may be chosen where the agency of a very few persons, and these naturally connected together, may, without foreign or extraneous assistance, afford matter for a tragedy. But, in the actual course of the peopled world, men are so crowded together, and their movements depend so much upon impulses foreign to themselves, that the action must often appear multiplied and complicated, and all that the author can do is, to preserve the interest uniform and undivided. Its progress may be likened to that of a brook through beautiful scenery. A judicious improver of the landscape would be certainly desirous to make its course visible, but not to cut off its beautiful undulations, or to compel it into a straight channel. He would follow the course of nature, and neither affect to conceal the smaller rills by which the stream was fed, nor bring them so much in view as to deprive the principal object of its consequence. We admit the difficulty inseparable from the dramatic art, and must grant, that the author runs some risk of losing sight of the main interest of the piece, by dwelling upon the subordinate accessories; but we contend, that the attention of the audience is still more likely to be fatigued by a bald and simple plot, to which, during the course of five acts, there must belong much speaking and little progress. And, in point of common sense and common feeling, that piece must always present unity of action which has unity of interest and feeling; which fixes the mind of the audience upon one train of thought and passion, to which every occurrence in the drama verges; and which is consummated and wound up by the final catastrophe.

The second dramatic unity is that of Time, about which the critics of various nations have disagreed. If taken in its strict and proper sense, it means that the time supposed to be consumed in the action represented, should not exceed that which is occupied by the actual representation. But even Aristotle extends the duration of the action to one revolution of the sun, and Corneille extends it to thirty hours, which is to the actual period of representation as ten to one. Boileau, a supereminent authority, thus lays down the rule for the unities of time and place:

> Que le lieu de la scene y soit fixe & marqué.
> Un Rimeur, sans peril, dela les Pirenées,
> Sur la scene en un jour renferme des années.
> La souvent le Heros d'un spectacle grossier,
> Enfant au premier aete, est Barbon au dernier,
> Mais nous, que la Raison à se regles engage,
> Nous voulons qu'avec art l'action se ménage :
> Qu'en un lieu, qu'en un jour, un seul fait accompli
> Tienne jusq'à la fin le Theatre rempli.

It has been triumphantly remarked, that in thus yielding up the strict letter of the precept—in allowing the three hours employed in acting a play to be multiplied into twenty-four or thirty,—the critics have retained nearly all the inconvenience of this famous rule, while they sacrificed its principle, and any advantage attached to its observance. The only benefit supposed to be attached to this unity is that of probability. We shall not at present inquire whether this is worth preserving at the cost of imposing heavy restrictions on dramatic genius. But granting the affirmative, probability is as much violated by squeezing the events of twenty-four hours into a period of only three, as if the author had exercised the still greater licence of the English and Spanish theatres. There is no charm in the revolution of the sun, which circumscribes within that particular period the events of a drama. When the magic circle drawn around the author by the actual date of representation is once obliterated, the argument grounded upon probability falls; and he may extend his narrative unconfined by any rule, except what may be considered as resolving itself into the unity of action. A week, a month, an year, years may be included in the course of the drama, provided always the poet has power so to rivet the attention of the audience on the passing scene, that the lapse of time shall pass unregarded. There must be none of those marked pauses which force upon the spectators' attention the breach of this unity. Still less ought the judicious dramatist to permit his piece to embrace such a space of time as shall necessarily produce the change on the persons of the characters ridiculed by Boileau. The extravagant conduct of the plot in the *Winter's Tale* has gone far to depreciate that drama which, in passages of detached beauty, is inferior to none of Shakespeare's, in the opinion of the best judges. It might perhaps be improved in acting, by performing the three first acts as a play, and the fourth and fifth as an afterpiece. Yet, even as it is now acted, who is it that, notwithstanding the cold objection arising out of the breach of unity, witnesses, without delight, the exquisite contrast betwixt the court and the hamlet, the fascinating and simple elegance of Perdita, or the witty rogueries of Autolycus? The poet is too powerful for the critic, and we lose the exercise of our judgment in the warmth of our admiration.

The faults of Shakespeare or of his age, we do not, however, recommend to the modern dramatist, whose modesty will certainly place him in his own estimation far beneath that powerful magician whose art could fascinate us even by means of deformity itself. But if for his own sake the author ought to avoid such gross violations of dramatic rule, the public, for theirs, ought not to tie him down to such severe limitations as must cramp, at least, if they do not destroy his power of affording them pleasure. If the whole five acts are to be compressed within the space of twenty-four hours, the events must, in the general case, be either so much crowded upon each other as to destroy the very probability which it is the purpose of this law to preserve; or, many of them being supposed to have happened before the commencement of the piece, must be detailed in narrative, which never fails to have a bad effect on the stage.

The same objections apply to the rigid enforcement of the third unity, that of Place; and, indeed, the French authors have used respecting it the licence of relaxing, in practice, the severity of their theory. They have frequently infringed the rule which they affirm to be inviolable; and their flexible creed permits the place to be changed, provided the audience are not transported out of the city where the scene is laid. This mitigation of doctrine, like that granted in the unity of time, is a virtual resignation of the principle contended for. Let us examine, however, upon what that principle is founded.

The rule, which prohibits the shifting the scene during the period of performance, was borrowed by the French from the ancients, without considering the peculiar circumstances in which it arose. First, We have seen already that, during the ancient drama, there was no division into acts, and that the action was only suspended during the songs of the chorus, who themselves represented a certain class of personages connected with the scene. The stage, therefore, was always filled; and a supposed change of place would have implied the violent improbability, that the whole chorus were transported, while in the sight of the spectators, and employed in the discharge of their parts, to the new scene of action. Secondly, There is evidence that in the *Eumenides* of Eschylus, and the *Ajax* of Sophocles, the scene is actually changed, in defiance of the presence of the chorus; and a much greater violation of probability is incurred than could have taken place in a modern theatre, where, before every change of scene, the stage is emptied of the performers. Thirdly, The ancients were less hardly pressed by this rule than the modern writers. From the extent of their theatres, and the size of their stages, the place of action was considerably larger, and might be held to include a wider extent than ours. The climate of Greece admitted of many things being transacted with propriety in the open air; and, finally, they had a contrivance for displaying the interior of a house or temple to the audience, which, if not an actual change of scene, was adapted to the same purpose.

If this long litigated question, therefore, is to be disposed of by precedent, we have shown that the rule of the ancients was neither absolute, nor did the circumstances of their stage correspond with those of ours; to which, it may be added, that the simple and inartificial structure of their plots seldom required a change of scene. But, surely, it is of less consequence to examine the practice of the ancients, than to consider how far it is founded upon truth, good taste, and general effect. Granting, therefore, that the supposed illusion, which transports the spectator to the actual scene of action, really exists, let us inquire whether, in sacrificing the privilege of an occasional change of scene, we do not run the risk of shocking the spectator, and disturbing his delightful dreams, by other absurdities and improbabilities, attendant necessarily on a scrupulous adherence to this restriction.

If the action is always to pass in the scene, some place of general resort must be adopted, a hall, antiroom, or the like. It can seldom be so fortunately selected but that much must be necessarily discussed there, which, in order to preserve any appearance of

probability, should be transacted elsewhere; that many persons must be introduced, whose presence must appear unnatural; and that much must be done there, which the very circumstances of the piece render totally absurd. Dennis has applied these observations with great force, and at the same time with great bitterness, in his critique upon *Cato*, which Johnson has quoted at length in his *Life of Addison*. The scene, it must be remembered, is laid, during the whole drama, with scrupulous attention to the classical rule, in the great hall of Cato's palace at Utica. Here the conspirators lay their plots, the lovers carry on their intrigues; and yet Sempronius, with great inconsistency, disguises himself as Juba, to obtain entrance into this vestibule, which was common to all. Here Cato retires to moralize, and chides his son for interrupting him, and, although he retires to stab himself, it is to this place that he is brought back to die. All this affords a striking proof how genius and taste can be fettered and embarrassed by a too pedantic observance of rules. Let no one suppose that the inconveniences arising from the rigid observance of the unity of place, occur in the tragedy of *Cato* alone; they might, in that case, be attributed to the inexperience or want of skill in the author. The tragedies of Corneille and Racine afford examples enough that the authors found themselves compelled to violate the rules of probability and common sense, in order to adhere to those of Aristotle. In the tragedy of *Cinna*, for example, the scene is laid in the Emperor's cabinet; and, in that very cabinet, compelled, doubtless, by the laws of unity, Amelia shouts forth aloud her resolution to assassinate the Emperor. It is there, too, that Maximus and Cinna confide to each other all the secrets of their conspiracy; and it is there, where, to render the impropriety more glaring, Cinna suddenly reflects upon the rashness of his own conduct:—

> Amis, dans ce palais on peut nous écouter;
> Et nous parlons peut-être avec trop d'imprudence,
> Dans un lieu si mal propre à notre confidence.

It would be an invidious, but no difficult task, to show that several of the *chefs d'œuvres* of the French drama are liable to similar objections; and that the awkward dilemmas in which the unity of place involves them, is far more likely to destroy the illusion of the performance, than the mere change of scene would have done. But we refer the reader to the *Dramaturgie* of Lessing upon this curious topic.

The main question yet remains behind, namely, whether such an illusion is actually produced in the minds of the audience by the best-acted play, as induces them to suppose themselves witnessing a reality;—an illusion, in short, so complete, as to suffer from the occasional extension of time or change of place in the course of the piece? We do not hesitate to say, that no such impression was ever produced on a sane understanding; and that the Parisian critic, in whose presence the unities are never violated, no more mistakes Talma for Nero, than a London citizen identifies Kemble with Coriolanus, or Kean with Richard III. The ancients, from the distance of the stage, and their mode of dressing and disguising their characters, might certainly approach a step nearer to reality; and, producing on their stage the very images of the deities they worshipped, speaking the language which they accounted proper to them, it is highly probable that, to minds capable of high excitation, there might be a shade of this illusion in their representations. The solemn distance of the stage, the continuous and uninterrupted action, kept the attention of the Greeks at once more closely rivetted, and more abstracted from surrounding circumstances. But, in the modern theatre, the rapid succession of intervals for reflection; the well-known features of the actors; the language which they speak differing frequently from that which belongs to the age and country where the scene is laid—interrupt, at every turn, every approximation to the fantastic vision of reality into which those writers who insist upon the strict observance of the unities, suppose the audience to be lulled. To use the nervous words of Johnson, "It is false, that any representation is mistaken for reality; that any dramatic fable in its materiality was ever credible, or, for a single moment, was ever credited." There is a conventional treaty between the author and the audience, that upon certain suppositions being granted by the latter, his powers of imagination shall be exerted for the amusement of the spectators. The postulates which are demanded, even upon the French theatre, and under the strictest model, are of no ordinary magnitude. Although the stage is lighted with lamps, the spectator must say with the subjugated Catherine,

> "I grant it is the sun that shines so bright."

The painted canvas must pass for a landscape; the well known faces of the performers for those of ancient Greeks, or Romans, or Saracens, and the present time for many ages distant. He that submits to such a convention ought not scrupulously to limit his own enjoyment; that which is supposed Rome in one act, may, in the next, be fancied Paris; and as for time, it is, to use the words of Dr Johnson, "of all modes of existence, most obsequious to imagination; a lapse of years is as easily conceived as a passage of hours. In contemplation we easily contract the time of real actions, and, therefore, willingly permit it to be contracted when we only see their imitation."

If dramatic representation does not produce the impression of reality, in what, it may be asked, consists its power? We reply, that its effects are produced by the powerful emotions which it excites in the minds of the spectators. The professors of every fine art operate their impressions in the same manner, though they address themselves to different organs. The painter exhibits his scene to the eye; the orator pours his thunder upon the ear; the poet awakens the imagination of his reader by written description; but each has the same motive, the hope, namely, of exciting in the reader, hearer, or spectator, a tone of feeling similar to that which existed in his own bosom, ere it was bodied forth by his pencil, tongue, or pen. It is the artist's object, in short, to tune the reader's imagination to the same pitch with his own; and to communicate, as well as colours and words can do, the same sublime sensations which had

dictated his own compositions. The tragedian attempts to attain this object still more forcibly, because his art combines those of the poet, orator, and artist, by storming, as it were, the imagination at once through the eye and the ear. Undoubtedly, a drama with such advantages, and with those of dresses and costume, approaches more nearly to actual reality; and, therefore, has a better chance of attaining its object, especially when addressing the sluggish and inert fancies of the multitude; although it may remain a doubtful question, whether, with all these means and appliances, minds of a high poetic temperature may not receive a more lively impression from the solitary perusal, than from the representation of one of Shakespeare's plays. But, to the most ignorant spectator, however unaccustomed to the trick of the scene, the excitement which his fancy receives, falls materially short of actual mental delusion. Even the sapient Partridge himself never thought of being startled at the apparition of the King of Denmark, which he knew to be only a man in a strange dress; it was the terror so admirably expressed by Garrick, which communicated itself to his feelings, and made him reverse the case of the fiends, and tremble without believing. In truth, the effects produced upon this imaginary character, as described by an excellent judge of human nature, exhibit, probably, the highest point of illusion to which theatrical exhibition can conduct a rational being. In an agony of terror which made his knees knock against each other, he never forgets that he is only witnessing a play. The presence of Mrs Millar and his master assures him against the reality of the apparition, yet he is no more able to subdue his terrors by this comfortable reflection, than we have been to check our tears, although, well aware, that the Belvidera, with whose sorrows we sympathized, was no other than our own inimitable Mrs Siddons. With all our passions and all our sympathies, we are still conscious of the ideal character of that which excites them; and it is probably this very consciousness of the unreality of scene that refines our sorrows into a melancholy, yet delicious emotion, and extracts from it that bitterness necessarily connected with a display of similar misery in actual life.

If, therefore, no illusion subsists of a character to be affected by a change of scene, or by the prolongation of the time beyond the rules of Aristotle, the very foundation of these unities is undermined; but, at the same time, every judicious author will use liberty with prudence.

If we are inclined to ascend to the origin of these celebrated rules, we ought not to be satisfied with the *ipse dixit* of a Grecian critic, who wrote so many centuries ago, and whose works have reference to a state of dramatic composition which has now no existence. Upon the revival of letters, indeed, the authority of Aristotle was considered as omnipotent; but even Boileau remonstrated against his authority when weighed with that of reason and common sense.

> " Un pedant envieré de sa vaine science,
> Tour herisse de Grec, tout bouffi d'arrogance,
> Et qui de mille auteurs retenus mot pour mot,
> Dans la teste entassez, n'a souvent fait qu' un sot,
> Croit qu' un livre fait tout, et que sans Aristote
> La raison ne voit goutte, et le bon sens radote."

The opinions of Aristotle must be judged of according to the opportunities and authorities which lay open before him; and from the high critical judgment he has displayed, we can scarce err in supposing he would have drawn different results, in different circumstances. Dr Drake, whose industry and taste have concentrated so much curious information respecting Shakespeare and his age, has quoted upon this topic a striking passage from Mr Morgan's *Essay on the Character of Falstaff.*

Speaking, says Dr Drake, of the magic influence which our poet almost invariably exerts over his auditors, Mr Morgan remarks, that " on such an occasion, a fellow like *Rymer*, * waking from his trance, shall lift up his constable's staff, and charge this great magician, this daring *practiser of arts inhibited*, in the name of Aristotle to surrender; whilst Aristotle himself, disowning his wretched officer, would fall prostrate at his feet and acknowledge his supremacy.—O supreme of dramatic excellence! (might he say) not to me be imputed the insolence of fools. The bards of *Greece* were confined within the narrow circle of the chorus, and hence they found themselves constrained to practise, for the most part, the precision, and copy the details, of nature. I followed them, and knew not that a larger circle might be drawn, and the drama extended to the whole reach of human genius. Convinced, I see that a more compendious *nature* may be obtained; a nature of *effects* only, to which neither the relation of places, or continuity of time, are always essential. Nature, condescending to the faculties and apprehensions of man, has drawn through human life a regular chain of visible causes and effects: But poetry delights in surprise, conceals her steps, seizes at once upon the heart, and obtains the sublime of things without betraying the rounds of her ascent. True poetry is *magic* not *nature;* an effect from causes hidden or unknown. To the magician I prescribed no laws; his law and his power are one; his power is his law. If his end is obtained, who shall question his course? Means, whether apparent or hidden, are justified in poesy by success; but then most perfect and most admirable when most concealed.—

" Yes, continues Mr Morgan, whatever may be the neglect of some, or the censure of others, there are those who firmly believe, that this wild, this uncultivated *barbarian*, as he has been called, has not yet obtained one half of his fame; and who trust that some new Stagyrite will arise, who, instead of pecking at the surface of things, will enter into the inward soul of his compositions, and expel, by the force of congenial feelings, those foreign impurities which have stained and disgraced his page. And as to those *spots* which still remain, they may perhaps become invisible, to those who shall seek them through the medium of his beauties, instead of looking for those beauties, as is too frequently done

* Rymer was a calumniator of Shakespeare.

through the smoke of some real or imputed obscurity. When the hand of time shall have brushed off his present editors and commentators, and when the very name of Voltaire, and even the memory of the language in which he has written, shall be no more, the Apalachian mountains, the banks of the Ohio, and the plains of Sciola, shall resound with the accents of this *barbarian.* In his native tongue he shall roll the genuine passions of nature; nor shall the griefs of *Lear* be alleviated, or the charms and wit of *Rosalind* be abated by *time.*" *

In adopting the views of those authors who have pleaded for the liberty of the poet, it is not our intention to deny, that great advantages may be obtained by the observance of the unities; not considering them as in themselves essential to the play; but only as points upon which the credibility and intelligibility of the action in some sort depends. We acknowledge, for example, that the author would be deficient in dramatic art, who should divide the interest of his piece into two or more separate plots, instead of combining it in one progressive action. We confess, moreover, that the author, who more violently extends the time or more frequently changes the place of representation than can be justified by the necessity of the story, and vindicated by his exertion of dramatic force, acts unwisely, in so far as he is likely to embarrass a great part of the audience, who, from imperfect hearing or slowness of comprehension, may find it difficult to apprehend the plot of his play. The latitude which we are disposed to grant, is regulated by the circumstances of the case, the interest of the plot, and, above all, the talents of the author. He that despises the praise of regularity which is attainable by study, cannot reckon on the indulgence of the audience, unless on the condition of indemnifying them by force of genius. If a definitive rule were to be adopted, we should say that it would certainly be judicious to place any change of place or extension of time at the beginning of a new act; as the falling of the curtain and cessation of the action has prepared the audience to set off, as it were, upon a new score. But we consider the whole of these points of propriety as secondary to the real purposes of the drama, and not as limitary of that gifted genius who can, in the whirlwind of his scene, bear the imagination of his audience along with him over the boundaries of place,

"While panting time toils after them in vain."

French notions of Tragi-comedy.

It is not upon the observance of the unities alone that the French found their pretensions to a classical theatre. They boast also to have discarded that intermixture of tragic and comic scenes, which was anciently universal upon the Spanish and English stages.

If it had been only understood by this reformation, that the French condemned and renounced that species of tragi-comedy, which comprehended two distinct plots, the one of a serious, the other of a humorous character, and these two totally unconnected, we give them full credit for their restriction. Dryden, in the *Spanish Friar,* and other pieces; and Southern, both in *Oronoko* and *Isabella,* as well as many other authors of their age, have in this particular transgressed unpardonably the unity of action. For, in the cases we have quoted, the combination of the two plots is so slight, that the serious and comic scenes separated, might each furnish forth a separate drama; so that the audience appear to be listening not to one play only, but to two dramatic actions independent of each other, although contained in the same piece. So far, therefore, we heartily agree in the rule which excludes such an unhappy interchange of inconsistent scenes, moving upon opposite principles and interests.

When, however, the French critics carry this rule farther, and proscribe the appearance of comic or inferior characters, however intimately connected with the tragic plot, we would observe, in the first place, that they run the risk of diminishing the reality of the scene; and secondly, that they exclude a class of circumstances essential to its beauty.

On the first point it must be observed, that the rule which imposes upon valets and subordinate personages the necessity of talking as harmonious verse and as elegant poetry as their masters, entirely ruins the probability of the action. Where all is elegant, nothing can be sublime; where all is ornamented, nothing can be impressive; where all is tuned to the same smooth *falsetto* of sentiment, nothing can be natural or real. By such an assimilation of manners and languages, we stamp fiction on the very front of our dramatic representation. The touches of nature which Shakespeare has exhibited in his lower and gayer characters, like the chastened back-ground of a landscape, increase the effect of the principal group. The light and fanciful humour of Mercutio serves, for example, to enhance and illustrate the romantic and passionate character of Romeo. Even the doating fondness and silly peevishness of the nurse tends to relieve the soft and affectionate character of Juliet, and to place her before the audience in a point of view which those who have seen Miss O'Neil perform Juliet, know how to appreciate. A contrast is effected, which a French author dared not attempt; but of which every bosom at once acknowledges the power and the truth. Let us suppose, that the gay and gallant Mercutio had as little character as the walking confident of a French hero, who echoes the hexameters of his friend in hexameters of a lower level; or let us suppose the nurse of Juliet to be a gentle Nora, as sublime in white linen as her principal in white satin; and let the reader judge whether the piece would gain in dignity any thing proportioned to what it must lose in truth and interest. The audience at once sympathizes with the friendship of Romeo and Mercutio, rendered more natural, and more interesting, by the very contrast of their characters; and each spectator feels as a passion,

* *Shakespeare and his Times,* by Nathan Drake, M. D. p. 553, 554, Vol. II.

not as a matter of reflection, that desire of vengeance which impels Romeo against Tibalt; for we acknowledge as an amiable and interesting individual, the friend whom he has lost by the sword of Capulet. Even the anilities of the nurse give a reality to the piece, which, whatever French critics may pretend, is much more seriously disturbed by inconsistency of manners, than by breach of their dramatic unities. "God forbid," says Mr Puff, in the *Critic*, "that, in a free country, all the fine words in the language should be engrossed by the higher characters of the piece." The French critics did not carry their ideas of equality quite so far; but they tuned the notes of their subalterns just one pitch lower than those of their principal characters, so that their language, similar in style, but lower in sentiment and diction, presents still that subordinate resemblance and correspondence to that of their superiors, which the worsted lace upon the livery of a servant bears to the embroidery upon the coat of his master.

It is not to mere expression which these remarks are confined; for if we consult the course of human life, we shall find that mirth and sorrow, and events which cause both, are more nearly allied than perhaps it is altogether pleasing to allow. Considered relatively to a spectator, an incident may often excite a mingled emotion, partaking at once of that which is moving, and that which is ludicrous; and there is no reader who has not, at some period of his life, met with events at which he hesitated whether to laugh or to cry. It remains to be proved, why scenes of this dubious, yet interesting description, should be excluded from the legitimate drama, while their force is acknowledged in that of human life. We acknowledge the difficulty of bringing them upon the scene with their full and corresponding effect. It was, perhaps, under this persuasion, that the fool, whose wild jests were too much the result of habit and practice to be subdued even by the terrors of the storm, has been banished from the terrific scene of King Lear. But, in yielding to this difficulty, the terrible contrast has been thus destroyed, in which Shakespeare exhibited the half-perceptions of the natural Fool, as contrasted with the assumed insanity of Edgar, and the real madness of the old King. They who prefer to this living variety of emotion, the cold uniformity of a French scene of passion, must be numbered among those who read for the pleasure of criticism, and without hope of partaking the enthusiasm of the poet.

While we differ from French criticism respecting the right to demand an accurate compliance with the unities, and decline to censure that casual intermixture of comic character which gives at once reality and variety to the drama, we are no less disposed to condemn the impertinent love-scenes, which these authors have, as a matter of etiquette, introduced into all their tragedies, however alien from the passion on which they are grounded. The French drama assumed its present form under the auspices of Louis XIV. who aimed at combining all the characters of a hero of romance. The same spirit which inspired the dull monotony of the endless *folios* of Scudery and Calprenede, seemed to dictate to Corneille, and even to Racine, those scenes of frigid metaphysical passion which encumber their best plays. We do not dispute the deep interest which attaches to the passion of love, so congenial to the human breast, when it forms the ground-work of the play; but it is intolerably nauseous to find a dull love tale mingled as an indispensable ingredient in every dramatic plot, however inconsistent with the rest of the piece. The *Amoureux* and *Amoureuse* of the piece come regularly forth to recite their common-places of gallantry, in language as cold as it is exaggerated, and as inconsistent with passion and feeling as with propriety and common sense. Even the horrid tale of Œdipus has the misplaced garnishment of a love intrigue between Theseus, brought there for no other purpose, and a certain Dircé whom, in the midst of the pestilence, he thus gallantly compliments:

> Quelque ravage affreux qu'etale ici la peste
> L'absence aux vrais amans est encore plus funeste.

The predominance of a passion which expresses itself so absurdly is all that the French have condescended to adopt from the age of chivalry, so rich in more dramatic stores; and they have borrowed it in all its pedantry, and without its tenderness and fire. Riccoboni has probably alleged the true reason for the introduction of these heavy scenes of love intrigue, which is, that at little expence of labour to the author, they fill up three quarters of the action of his play. We quote from the French version, as that immediately before us, and most generally intelligible: "*Par exemple, ôtons de* NICOMEDE *les dix scenes de* LAODICE*; de* L'OEDIPE*, les dix scenes de* DIRCE*; de* POLIEUCTE*, les scenes d'amour de* SEVERE*; de la* PHEDRE *de Monsieur Racine les six scenes d'*ARICIE*, et nous verrons que non seulement l'action ne sera point interrompuë, mais qu'elle en sera plus vive; en sorte que l'on verra manifestement, que ces scenes de tendresses n'ont servi qu'à ralentir l'action de la piéce, à la refroidir, et à rendre les heros moins grand. Si après ce deux meilleurs Tragedies de la France, on examine tous les autres, on connoitra bien mieux cette verité. Lorsque l'amour fait le sujet de la tragedie, ce sentiment, si interessant par lui-meme occupe le scene avec raison; j'aime l'amour de* PHEDRE, *mais de* PHEDRE *seule.*" Under this thraldom, the fetters of the French stage long laboured, notwithstanding the noble example of *Athalie,* the chef d'œuvre of Racine. By the example of Voltaire, in one or two of his best pieces, they have of late ventured occasionally to discard their uninteresting Cupid, whose appearance on the stage as a matter of course and of ceremony, produced as little effect as when his altar and godhead are depicted on the semicircle of a fan.

We have already observed, that the refined, artificial, and affected character of the French tragedy, arose from its immediate connection with the pleasures and with the presence of an absolute sovereign. From the same circumstance, however, the French stage derived several advantages. A degree of discipline, unknown in other theatres, was early introduced among the French actors, and those of a subordinate rank, who, on the English stage, sometimes

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exhibit intolerable, contemptuous, and wilful negligence, become compelled on that of France, to pay the same attention to their parts as their superiors, and to exert what limited talents they possess in the subordinate parts to which they are adapted. The effect of this common diligence upon the scene, is a general harmony and correspondence in its parts, which never fails to strike a stranger with admiration.

The Royal protection, also, early produced on the Parisian stage, an improved and splendid style of scenery, decoration, and accompaniments. The scenes and machinery which they borrowed from Italy, they improved with their usual alert ingenuity. They were still further improved under the auspices of Voltaire, who had the sole merit of introducing natural and correct costume. Before his time the actors, whether Romans or Scythians, appeared in the full dress of the French court; and Augustus himself was represented in a huge full-bottomed wig, surmounted by a crown of laurel. The strict national costume introduced by Voltaire is now observed. That author has also the merit of excluding the idle crowd of courtiers and men of fashion, who thronged the stage during the time of representation, and formed a sort of semicircle round the actors, leaving them thus but a few yards of an area free for performance, and disconcerting at once the performers and the audience, by the whimsical intermixture of players and spectators. The nerves of those pedants who contended most strenuously for the illusion of the scene, and who objected against its being interrupted by an occasional breach of the dramatic unities, do not appear to have suffered from the presence of this singular chorus.

Corneille.

It was not decoration and splendour alone which the French stage owed to Louis XIV. Its principal obligation was for that patronage which called forth in its service the talents of Corneille and Racine, the Homer and Virgil of the French drama. However constrained by pedantic rules; however held back from using that infinite variety of materials, which national and individual character presented to them; however frequently compelled by system to adopt a pompous, solemn, and declamatory style of dialogue—these distinguished authors still remain the proudest boast of the classical age of France, and a high honour to the European republic of letters. It seems probable that Corneille, if left to the exercise of his own judgment, would have approximated more to the romantic drama. The *Cid* possesses many of the charms of that species of composition. In the character of Don Gourmaz, he has drawn a national portrait of the Spanish nobility, for which very excellence he was subjected to the censure of the Academy, his national court of criticism. In a general point of view, he seems to have been ambitious of overawing his audience by a display of the proud, the severe, the ambitious, and the terrible. Tyrants and conquerors have never sat to a painter of greater skill; and the romantic tone of feeling which he adopts in his more perfect characters is allied to that of chivalry. But Corneille was deficient in tenderness, in dramatic art, and in the power of moving the passions. His fame, too, was injured by the multiplicity of his efforts to extend it. Critics of his own nation have numbered about twenty of his dramas, which have little to recommend them; and no foreign reader is very likely to verify or refute the censure, since he must previously read them to an end.

Racine.

Racine, who began to write when the classical fetters were clenched and rivetted upon the French drama, did not make that effort of struggling with his chains, which we observe in the elder dramatist; he was strong where Corneille evinced weakness, and weak in the points where his predecessor showed vigour. Racine delineated the passion of love with truth, softness, and fidelity; and his scenes of this sort form the strongest possible contrast with those in which he, as well as Corneille, sacrificed to the dull Cupid of metaphysical romance. In refinement and harmony of versification, Racine has hitherto been unequalled; and his *Athalie* is, perhaps, likely to be generally acknowledged as the most finished production of the French drama.

Voltaire.

Subsequent dramatists, down to the time of Voltaire, were contented with imitating the works of these two great models; until the active and ingenious spirit of that celebrated author seems tacitly to have meditated further experimental alterations than he thought it prudent to defend or to avow. His extreme vivacity and acute intellect were mingled, as is not unfrequent in such temperaments, with a certain nervous timidity, which prevented him from attempting open and bold innovation, even where he felt compliance with existing rules most inconvenient and dispiriting. He borrowed, therefore, liberally from Shakespeare, whose irregularities were the frequent object of his ridicule; and he did not hesitate tacitly to infringe the dramatic unities in his plays, while in his criticism he holds them up as altogether inviolable. While he altered the costume of the stage, and brought it nearer to that of national truth, he made one or two irresolute steps towards the introduction of national character. If we were, indeed, to believe the admirers of Corneille, little remained to be done in this department; he had already, it is said, taught his Romans to speak as Romans, and his Greeks as Greeks; but of such national discrimination foreigners are unable to perceive a trace. His heroes, one and all, talk like men of no peculiar character or distinct age and nation; but like the other heroes of the French dramatic school, are "all honourable men;" who speak in high, grave, buskined rhimes, where an artificial brilliancy of language, richness of metaphor, and grandeur of sentiment, are substituted for that concise and energetic tone of dialogue, which shows at once the national and individual character of the personage who uses it. In *Mahomet*, *Alzire*, and one or two other pieces, Voltaire has attempted some discrimination of national character; the ground-work, however, is still French; and, under every disguise, whether of the turban of the Ottoman, the feathery crown of the savage, or the silk tunic of the Chinese, the character of that singular people can be easily recognized. Voltaire probably saw the deficiency of the national drama with

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his usual acuteness; but, like the ancient philosophers, he contentedly joined in the idolatry which he despised.

It seems, indeed, extremely doubtful, whether the French tragedy can ever be brought many steps nearer to nature. That nation is so unfortunate as to have no poetical language; so that some degree of unnatural exaltation of sentiment is almost necessary to sustain the tone of tragedy at a pitch higher than that of ordinary life. The people are passionately fond of ridicule; their authors are equally afraid of incurring it: they are aware, like their late ruler, that there is but one step betwixt the sublime and the ridiculous; and they are afraid to aim at the former, lest their attempt falling short, should expose them to derision. They cannot reckon on the mercy or enthusiasm of their audience; and while they banish combats and deaths. and even violent action of any kind from the stage, this seems chiefly on account of the manifest risk that a people, more alive to the ludicrous than the lofty, might laugh when they should applaud. The drunken and dizzy fury with which Richard, as personated by Kean, continues to make the motion of striking after he has lost his weapon, would be caviare to the Parisian parterre. Men must compound with their poets and actors, and pardon something like extravagance, on the score of enthusiasm. But if they are nationally dead to that enthusiasm, they resemble a deaf man listening to eloquence, who is more likely to be moved to laughter by the gestures of the orator, than to catch fire at his passionate declamation.

Above all, the French people are wedded to their own opinions. Each Parisian is, or supposes himself, master of the rules of the critical art; and whatever limitations it imposes on the author, the spectators receive some indemnification from the pleasure of sitting in judgment upon him. To require from a dancer to exhibit his agility without touching any of the lines of a diagram chalked on the floor, would deprive the performance of much ease, strength, and grace; but still the spectator would feel a certain interest in watching the dexterity with which the artist avoided treading on the interdicted limits, and a certain pride in detecting occasional infringements. In the same manner, the French critic obtains a triumph from watching the transgressions of the dramatic poet against the laws of Aristotle; equal, perhaps, to the more legitimate pleasure he might have derived from the unfettered exercise of his talents. Upon the whole, the French tragedy, though its regulations seem to us founded in pedantry, and its sentiments to belong to a state of false and artificial refinement, contains, nevertheless, passages of such perfect poetry and exquisite moral beauty, that to hear them declaimed with the art of Talma, cannot but afford a very high pitch of intellectual gratification.

French Comedy.

The French comedy assumed a regular shape about the same period with the tragedy; and Moliere was in his department what Corneille and Racine were in theirs; an original author, approached in excellence by none of those that succeeded him. The form which he assumed for a model was that of the comedy of Menander; and he has copied pretty closely some pieces from the Latin stage. Moliere was endowed by nature with a rich fund of comic humour, which is nowhere more apparent than in those light pieces which are written upon the plan of the Italian masked comedy. In these he has introduced the jealous old Pantaloon; the knavish and mischievous Servant, and some of its other characters. In his regular comedy he soared to a higher pitch. Before his time the art had sought its resources in the multiplicity and bustle of intrigue, escape, and disguise,—of at best, in a comic dialogue, approaching to mere buffoonery. Moliere's satire aimed at a nobler prey; he studied mankind for the purpose of attacking those follies of social life which are best exposed by ridicule. The aim of few satirists has been so legitimate, or pursued with such success. Female vanity, learned pedantry, unreasonable jealousy, the doating and disgraceful passions of old men, avarice, coquetry, slander, the quacks who disgrace medicine, and the knaves who prostitute the profession of the law, were the marks at which his shafts were directed.

Moliere's more regular comedies are limited by the law of unities, and finished with great diligence. It is true, the author found it sometimes necessary tacitly to elude the unity of place, which he durst not openly violate; but, in general, he sacrifices probability to system. In the *Ecole des Femmes*, Arnolph brings his wife into the street, out of the room in which his jealousy has imprisoned her, in order to lecture her upon the circumspection due to her character; which absurdity he is guilty of, that the scene may not be shifted from the open space before his door to her apartment. In general, however, it may be noticed, that the critical unities impose much less hardship upon the comic than upon the tragic poet. It is much more easy to reconcile the incidents of private life to the unities of time and place, than to compress within their limits the extensive and prolonged transactions which comprehend the revolution of kingdoms and fate of monarchs. What influence, however these rules do possess, must operate to cramp and embarrass the comic as well as the tragic writer; to violate and disunite those very probabilities which they affect to maintain; and to occasion a thousand real absurdities rather than grant a conventional licence, which seems essential to the freedom of the drama.

The later comic authors of France seem to have abandoned the track pointed out by Moliere, as if in despair of approaching his excellence. Their comedy, compared with that of other nations, and of their great predecessor, is cramped, and tame, and limited. In this department, as in tragedy, the stage experienced the inconvenience arising from the influence of the Court. The varied and unbounded field of comic humour which the passions and peculiarities of the lower orders presents, was prohibited, as containing subjects of exhibition too low and vulgar for a monarch and his courtiers; and thus the natural, fresh, and varied character of comedy was flung aside, while the heartless vices and polished follies of the great world were substituted in its place. Schle-

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gel has well observed, that the object of French comedy "is no longer life but society; that perpetual negotiation between conflicting vanities which never ends in a sincere treaty of peace; the embroidered dress, the hat under the arm, and the sword by the side, essentially belong to them; and the whole of the characterization is limited to the folly of the men and the coquetry of the women."

It is scarce in nature that a laughter-loving people should have remained satisfied with an amusement so dull and insipid as their regular comedy. A few years preceding the revolution, and while the causes of that event were in full fermentation, the *Marriage of Figaro* appeared on the stage. It is a comedy of intrigue; and the dialogue is blended with traits of general and political satire, as well as with a tone of licentiousness, which was till then a stranger to the French stage. It was received with a degree of enthusiastic and frantic popularity which nothing but its novelty could have occasioned, for there is little real merit in the composition. Frederick of Prussia, and other admirers of the old theatrical school, were greatly scandalized at so daring an innovation on the regular French comedy. The circumstances which followed have prevented Beaumarchais' example from being imitated; and the laughers have consoled themselves with inferior departments of the drama. Accordingly, we find the blank supplied by farces, comic operas, and dramatic varieties, in which plots of a light, flimsy, and grotesque character are borne out by the comic humour of the author and comic skill of the actor. Brunet, a comedian of extraordinary powers in this cast of interludes, has at times presumed so far upon his popularity as to season his farce with political allusions. It will scarce be believed that he aimed several shafts at Napoleon when in the height of his power. The boldness, as well as the wit of the actor, secured him the applause of the audience; and such a hold had Brunet of their affections, that an imprisonment of a few hours was the greatest punishment which Bonaparte ventured to inflict upon him. But whatever be the attachment shown to the art in general, the French, like ourselves, rest the character of their theatre chiefly upon the ancient specimens of art; and the regular tragedy, as well as comedy, seems declining in that kingdom.

English Drama.

As the drama of France was formed under the patronage of the monarch, and bears the strongest proofs of its courtly origin, that of England, which was encouraged by the people at large, retains equally unequivocal marks of its popular descent. Its history must naturally draw to some length, as being that part of our essay likely to be most interesting to the reader. In part, however, we have paved the way for it by the details common to the rise of dramatic art in the other nations of Europe. We shall distinguish the English drama as divided into four periods, premising that this is merely a general and not a precise division. The taste which governed each period, and the examples on which it is grounded, will usually be found to have dawned in the period preceding that in which it was received and established.

I. From the revival of the theatre until the great civil war.

II. From the Restoration to the reign of Queen Anne.

III. From the earlier part of the last century down to the present reign.

IV. The present state of the British drama.

First period of the English Drama.

I. The drama of England commenced, as we have already observed, upon the Spanish model. *Ferrex and Porrex* was the first composition approaching to a regular tragedy; and it was acted before Queen Elizabeth, upon the 18th day of January 1561, by the gentlemen of the Inner Temple. It partakes rather of the character of a historical than of a classical drama; although more nearly allied to the latter class, than the chronicle plays which afterwards took possession of the stage. We have already recorded Sir Philip Sidney's commendation of this play, which he calls by the name of *Gorboduc*, from one of the principal characters. Acted by a learned body, and written in great part by Lord Sackville, the principal author of the *Mirror for Magistrates*, the first of English tragedies assumed in some degree the honours of the learned buskin; but although a chorus was presented according to the classical model, the play was free from the observance of the unities; and contains many irregularities severely condemned by the regular critics.

English comedy, considered as a regular composition, is said to have commenced with *Gammer Gurton's Needle*. This "right pithy, pleasant and merry comedy," was the supposed composition of John Still, Master of Arts, and afterwards Bishop of Bath and Wells. It was acted in Christ-Church College, Cambridge, in 1575. It is a piece of low humour; the whole jest turning upon the loss and recovery of the needle with which Gammer Gurton was to repair the breeches of her man Hodge; but, in point of manners, it is a great curiosity, as the *curta suppellex* of our ancestors is scarcely any where so well described. The popular characters also, the Sturdy Beggar, the Clown, the Country Vicar and the Shrew of the sixteenth century, are drawn in colours taken from the life. The unity of time, place, and action, are observed through the play with an accuracy of which France might be jealous. The time, is a few hours—the place, the open square of the village before Gammer Gurton's door—the action, the loss of the needle—and this followed by the search for and final recovery of that necessary implement, is intermixed with no other thwarting or subordinate interest, but is progressive from the commencement to the conclusion.

It is remarkable, that the earliest English tragedy and comedy are both works of considerable merit; that each partakes of the distinct character of its class; that the tragedy is without intermixture of comedy; the comedy without any intermixture of tragedy.

These models were followed by a variety of others, in which no such distinctions were observed. Numerous theatres sprung up in different parts of the metropolis, opened upon speculation by distinct troops of performers. Their number shows how much they interested public curiosity; for men ne-

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ver struggle for a share in a losing profession. They acted under licences, which appear to have been granted for the purpose of police alone, not of exclusive privilege or monopoly; since London contained, in the latter part of the sixteenth century, no fewer than fourteen distinct companies of players, with very considerable privileges and remunerations. See Drake's *Shakespeare and his Times*, Vol. II. p. 205.

The public, therefore, in the widest sense of the word, was at once arbiter and patron of the drama. The companies of players who traversed the country, might indeed assume the name of some peer or baron, for the sake of introduction or protection; but those of the metropolis do not, at this early period of our dramatic history, appear to have rested in any considerable degree upon learned or aristocratic privilege. Their licence was obtained from the crown, but their success depended upon the voice of the people; and the pieces which they brought forward were, of course, adapted to popular taste. It followed necessarily that histories and romantic dramas were the favourites of the age. A general audience in an unlearned age requires rather amusement than conformity to rules, and is more displeased with a tiresome uniformity than shocked with the breach of all the unities. The players and dramatists, before the rise of Shakespeare, followed, of consequence, the taste of the public; and dealt in the surprising, elevating, and often bombastic incidents of tragedy, as well as in the low humour and grotesque incident of the comic scene. Where these singly were found to lack attraction, they mingled them together and dashed their tragic plot with an under-intrigue of the lowest buffoonery, without any respect to taste or congruity.

The clown was no stranger to the stage; he interfered, without ceremony, in the most heart-rending scenes, to the scandal of the more learned spectators.

> Now lest such frightful shows of fortune's fall,
> And bloody tyrant's rage should chance appall
> The death-struck audience, 'midst the silent rout,
> Comes leaping in a self-misformed lout,
> And laughs and grins, and frames his mimic face,
> And jostles straight into the prince's place;
> Then doth the theatre echo all aloud,
> With gladsome noise of that applauding crowd,
> A goodly hotchpotch, where vile russettings
> Are matched with monarchs and with mighty kings.

An ancient stage-trick, illustrative of the mixture of tragic and comic action in Shakespeare's time, was long preserved in the theatre. Henry IV. holding council before the battle of Shrewsbury, was always represented as seated on a drum; and when he rose and came forward, the place was occupied by Falstaff, which seldom failed to produce a laugh from the galleries. The taste and judgment of the author himself was very different. During the whole scene, Falstaff gives only once, and under irresistible temptation, the rein to his petulant wit, and it is instantly checked by the prince; to whom, by the way, and not to the king, his words ought to be addressed.

Drama. Shakespeare.

The English stage might be considered equally without rule and without model when Shakespeare arose. The effect of the genius of an individual upon the taste of a nation is mighty; but that genius, in its turn, is formed according to the opinions prevalent at the period when it comes into existence. Such was the case with Shakespeare. With an education more extensive, and a taste refined by the classical models, it is probable that he also, in admiration of the ancient drama, might have mistaken the form for the essence, and subscribed to those rules which had produced such masterpieces of art. Fortunately for the full exertion of a genius, as comprehensive and versatile as intense and powerful, Shakespeare had no access to any models of which the commanding merit might have controlled and limited his own exertions. He followed the path which a nameless crowd of obscure writers had trodden before him; but he moved in it with the grace and majestic step of a being of a superior order; and vindicated for ever the British theatre from a pedantic restriction to classical rule. Nothing went before Shakespeare which in any respect was fit to fix and stamp the character of a national drama; and certainly no one will succeed him capable of establishing, by mere authority, a form more restricted than that which Shakespeare used.

Such is the action of existing circumstances upon genius, and the re-action of genius upon future circumstances. Shakespeare and Corneille was each the leading spirit of his age; and the difference between them is well marked by the editor of the latter. "*Corneille est inégal comme Shakespeare, et plein de genie comme lui: mais le genie de Corneille étoit à celui de Shakespeare ce qu'un seigneur est à l'egard d'un* homme *de* peuple *ne avec le même esprit que lui.*" This distinction is strictly accurate, and contains a compliment to the English author which, assuredly, the critic did not intend to make. Corneille wrote as a courtier, circumscribed within the imaginary rules and ceremonies of a court, as a chicken is by a circle of chalk drawn round it. Shakespeare, composing for the amusement of the public alone, had within his province, not only the inexhaustible field of actual life, but the whole ideal world of fancy and superstition;—more favourable to the display of poetical genius than even existing realities. Under the circumstances of Corneille, Shakespeare must have been restricted to the same dull, regular, and unvaried system. He must have written, not according to the dictates of his own genius, but in conformity to the mandate of some *intendant des menus plaisirs*; or of some minister of state, who, like Cardinal Richelieu, thought he could write a tragedy because he could govern a kingdom. It is not equally clear to what height Corneille might have ascended, had he enjoyed the national immunities of Shakespeare. Each pitched down a land-mark in his art. The circle of Shakespeare was so extended, that it is with advantage liable to many restrictions; that of Corneille included a narrow limit, which his successors have deemed it unlawful to extend.

It is not our intention, within the narrow space to which our Essay is necessarily limited, to enlarge

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upon the character and writings of Shakespeare. We can only notice his performances as events in the history of the theatre—of a gigantic character, indeed, so far as its dignity, elevation, and importance are considered; but, in respect of the mere practice of the drama, rather fixing and sanctioning, than altering or reforming those rules and forms which he found already established. This we know, for certain, that those historical plays or chronicles, in which Shakespeare's muse has thrown a never-fading light upon the history of his country, did, almost every one of them, exist before him in the rude shape of dry dialogue and pitiful buffoonery, stitched into scenes by the elder play-wrights of the stage. His romantic dramas exhibit the same contempt of regularity which was manifested by Marlow, and other writers; for where there was abuse or extreme licence upon the stage, the example of Shakespeare may be often quoted as its sanction, never as tending to reform it. In these particulars the practice of our immortal bard was contrasted with that of Ben Jonson, a severe and somewhat pedantic scholar;—a man whose mind was coarse, though capable both of strength and elevation, and whose strong perception of comic humour was tinctured with vulgarity.

Jonson.

Jonson's tragic strength consists in a sublime, and sometimes harsh, expression of moral sentiment; but displays little of tumultuous and ardent passion, still less of tenderness or delicacy; although there are passages in which he seems adequate to expressing them. He laboured in the mine of the classics, but overloaded himself with the ore, which he could not, or would not, refine. His *Cataline* and *Sejanus* are laboured translations from Cicero, Sallust, and Tacitus, which his own age did not endure, and which no succeeding generation will be probably much tempted to revive. With the stern superiority of learning over ignorance, he asserted himself a better judge of his own productions, than the public which condemned him, and haughtily claimed the laurel which the public suffrage often withheld; but the world has as yet shown no disposition to reverse the opinion of their predecessors.

In comedy, Jonson made some efforts partaking of the character of the older comedy of the Grecians. In his *Tale of a Tub* he follows the path of Aristophanes, and lets his wit run into low buffoonery, that he might bring upon the stage Inigo Jones, his personal enemy. In Cynthia's *Revells*, and the *Staple of News*, we find him introducing the dull personification of abstract passions and qualities, and turning legitimate comedy into an allegorical mask. What interest can the reader have in such characters as the three Penny boys, and their transactions with the Lady Pecunia? Some of Jonson's more legitimate comedies may be also taxed here with filthiness of language; of which disgusting attribute his works exhibit more instances, than any English writer of eminence, excepting Swift. Let us, however, be just to a master-spirit of his age. The comic force of Jonson was strong, marked, and peculiar; and he excelled even Shakespeare himself in drawing that class of truly English characters, remarkable for peculiarity of *humour*—that is, for some mode of thought, speech, and behaviour, superinduced upon the natural disposition by profession, education, or fantastical affectation of singularity. In blazoning these forth with their natural attributes and appropriate language, Ben Jonson has never been excelled, and his works every where exhibit a consistent and manly moral, resulting naturally from the events of the scene.

It must also be remembered, that, although it was Jonson's fate to be eclipsed by the superior genius, energy, and taste of Shakespeare, yet those advantages which enabled him to maintain an honourable though an unsuccessful struggle, were of high advantage to the drama. Jonson was the first who showed, by example, the infinite superiority of a well-conceived plot, all the parts of which bore upon each other, and forwarded an interesting conclusion, over a tissue of detached scenes, following without necessary connection or increase of interest. The plot of the *Fox* is admirably conceived; and that of the *Alchymist*, though faulty in the conclusion, is nearly equal to it. In the two comedies of *Every Man in his Humour*, and *Every Man out of his Humour*, the plot deserves much less praise, and is deficient at once in interest and unity of action; but in that of the *Silent Woman*, nothing can exceed the art with which the circumstance upon which the conclusion turns is, until the very last scene, concealed from the knowledge of the reader, while he is tempted to suppose it constantly within his reach. In a word, Jonson is distinguished by his strength and stature, even in those days when there were giants in the land; and affords a model of a close, animated, and characteristic style of comedy, abounding in moral satire, and distinguished at once by force and art, which was afterwards more cultivated by English dramatists, than the lighter, more wild, and more fanciful department in which Shakespeare moved, beyond the reach of emulation.

The general opinion of critics has assigned genius as the characteristic of Shakespeare, and art as the appropriate excellence of Jonson; not, surely, that Jonson was deficient in genius, but that art was the principal characteristic of his laborious scenes. We learn from his own confession, and from the panegyrics of his friends, as well as the taunts of his enemies, that he was a slow composer; the natural result of laborious care is jealousy of fame; for that which we do with labour we value highly when achieved. Shakespeare, on the other hand, appears to have composed rapidly and carelessly; and, sometimes, even without considering, while writing the earlier acts, how the catastrophe was to be huddled up, in that which was to conclude the piece. We may fairly conclude him to have been indifferent about fame, who would take so little pains to win it. Much, perhaps, might have been achieved by the union of these opposed qualities, and by blending the art of Jonson with the fiery invention and fluent expression of his great contemporary. But such an union of opposite excellencies in the same author was hardly to be expect-

ed; nor, perhaps, would the result have proved altogether so favourable, as might at first view be conceived. We should have had more perfect specimens of the art; but they must have been much fewer in number; and posterity would certainly have been deprived of that wild luxuriance of dramatic excellencies and poetic beauties, which, like wild flowers upon a common field, lie scattered profusely among the unacted plays of Shakespeare.

Massinger.

Although incalculably superior to his contemporaries, Shakespeare had successful imitators, and the art of Jonson was not unrivalled. Massinger appears to have studied the works of both, with the intention of uniting their excellencies. He knew the strength of plot; and although his plays are altogether irregular, yet he well understood the advantage of a strong and defined interest; and in unravelling the intricacy of his intrigues, he often displays the management of a master. Art, therefore, not perhaps in its technical, but in its most valuable sense, was Massinger's as well as Jonson's; and, in point of composition, many passages of his plays are not unworthy of Shakespeare. Were we to distinguish Massinger's peculiar excellence, we should name that first of dramatic attributes, a full conception of character, a strength in bringing out, and consistency in adhering to it. He does not, indeed, always introduce his personages to the audience, in their own proper character; it dawns forth gradually in the progress of the piece, as in the hypocritical Luke, or in the heroic Marullo. But, upon looking back, we are always surprised and delighted to trace from the very beginning, intimations of what the personage is to prove, as the play advances. There is often an harshness of outline, however, in the character of this dramatist, which prevents their approaching to the natural and easy portraits bequeathed us by Shakespeare.

Beaumont and Fletcher.

Beaumont and Fletcher, men of remarkable talent, seemed to have followed Shakespeare's mode of composition, rather than Jonson's, and thus to have altogether neglected that art which Jonson taught, and which Massinger in some sort practised. They may, indeed, be rather said to have taken for their model the boundless licence of the Spanish stage, from which many of their pieces are expressly and avowedly derived. The acts of their plays are so detached from each other, in substance and consistence, that the plot scarce can be said to hang together at all, or to have, in any sense of the word, a beginning, progress, and conclusion. It seems as if the play began, because the curtain rose, and ended because it fell; the author, in the meantime, exerting his genius for the amusement of the spectators, pretty much in the same manner, as, in the *Scenario* of the Italians, by the actors filling up with their extempore wit, the scenes chalked out for them. To compensate for this excess of irregularity, the plays of Beaumont and Fletcher have still an high poetical value. If character be sometimes violated, probability discarded, and the interest of the plot neglected, the reader is, on the other hand, often gratified by the most beautiful description, the most tender and passionate dialogue; a display of brilliant wit and gaiety, or a feast of comic humour. These attributes had so much effect on the public, that, during the end of the seventeenth and the beginning of the eighteenth centuries, many of Beaumont and Fletcher's plays had possession of the stage, while those of Shakespeare were laid upon the shelf.

Shirley and others.

Shirley, Ford, Webster, Decker, and others, added performances to the early treasures of the English drama, which abound with valuable passages. There never, probably, rushed into the lists of literary competition together, a band more distinguished for talent. If the early drama be inartificial and unequal, no nation, at least, can show so many detached scenes, and even acts of distinguished poetical merit. One powerful cause seems to have produced an effect so marked and distinguished; to wit, the universal favour of a theatrical public, which daily and nightly thronged the numerous theatres then open in the city of London.

Cause of the abundance of Dramatic Talent in this period.

In considering this circumstance, it must above all be remembered, that these numerous audiences crowded, not to feast their eyes upon show and scenery, but to see and hear the literary production of the evening. The scenes which the stage exhibited, were probably of the most paltry description. Some rude helps to the imagination of the audience might be used, by introducing the gate of a castle or town;—the monument of the Capulets, by sinking a trap-door, or by thrusting in a bed. The good-natured audience readily received these hints, with that conventional allowance, which Sir Philip Sidney had ridiculed, and which Shakespeare himself has alluded to, when he appeals from the poverty of theatrical representation to the excited imagination of his audience.

> ——— Can this cockpit hold
> The vasty fields of France? Or may we cram
> Within this wooden O, the very casques
> That did affright the air at Agincourt?
> O, pardon! since a crooked figure may
> Attest, in little space, a million;
> And let us, ciphers to this great account,
> On your imaginary forces work;
> Suppose, within the girdle of these walls
> Are now confin'd two mighty monarchies,
> Whose high upreared and abutting fronts
> The perilous narrow ocean parts asunder;
> Printing their proud hoofs i' the receiving earth.
> For 'tis your thoughts that now must deck our kings,
> Carry them here and there; jumping o'er times;
> Turning the accomplishment of many years
> Into an hour-glass:———

Such were the allowances demanded by Shakespeare and his contemporaries from the public of their day, in consideration of the imperfect means and appliances of their theatrical machinery. Yet the deficiency of scenery and show, which, when existing in its utmost splendour, divides the interest of the piece in the mind of the ignorant, and rarely affords much pleasure to a spectator of taste, may have been rather an advantage to the infant drama. The spectators having nothing to withdraw their attention from the immediate business of the piece, gave it their full and uninterrupted attention. And here it may not be premature to inquire into the characteristical difference between the audiences of the present day, and those earlier theatrical ages, when the drama

boasted not only the names of Shakespeare, of Massinger, of Jonson, of Beaumont and Fletcher, of Shirley, of Ford, and others of subordinate degree; the meanest of whom shows occasionally more fire than warms whole reams of modern plays. This will probably be found to rest on the varied and contrasted feelings with which the audience of ancient and that of modern days attend the progress of the scene.

Nothing, indeed, is more certain, than that the general cast of theatrical composition must receive its principal bent and colouring from the taste of the audience:

> The drama's laws, the drama's patrons give;
> For those who live to please, must please to live.

But though this be an undeniable, and in some respects a melancholy truth, it is not less certain, that genius, labouring in behalf of the public, possesses the power of re-action, and of influencing, in its turn, that taste to which it is in some respects obliged to conform; while, on the other hand, the play-wright, who aims only to catch the passing plaudit and the profit of a season, by addressing himself exclusively to the ruling predilections of the audience, degrades the public taste still farther, by the gross food which he ministers to it; unless it shall be supposed that he may contribute involuntarily to rouse it from its degeneracy, by cramming it even to satiety and loathing. This action, therefore, and re-action of the taste of the age on dramatic writing, and *vice versa*, must be both kept in view, when treating of the difference betwixt the days of Shakespeare and our own.

Perhaps it is the leading distinction betwixt the ancient and modern audiences, that the former came to listen, and to admire; to fling the reins of their imaginations into the hands of the author and actors, and to be pleased, like the reader to whom Sterne longed to do homage, "they knew not why, and cared not wherefore." The novelty of dramatic entertainments (for there elapsed only about twenty years betwixt the date of *Gammer Gurton's Needle*, accounted the earliest English play, and the rise of Shakespeare), must have had its natural effect upon the audience. The sun of Shakespeare arose almost without a single gleam of intervening twilight; and it was no wonder that the audience, introduced to this enchanting and seductive art at once, under such an effulgence of excellence, should have been more disposed to wonder than to criticise; to admire —or rather to adore—than to measure the height, or ascertain the course of the luminary which diffused such glory around him. The great number of theatres in London, and the profusion of varied talent which was dedicated to this service, attest the eagerness of the public to enjoy the entertainments of the scene. The ruder amusements of the age lost their attractions; and the royal bear-ward of Queen Elizabeth lodged a formal complaint at the feet of her majesty, that the play-houses had seduced the audience from his periodical bear-baitings! This fact is worth a thousand conjectures; and we can hardly doubt, that the converts, transported by their improving taste from the bear-garden to the theatre, must, generally speaking, have felt their rude minds subdued, and led captive by the superior intelligence, which not only placed on the stage at pleasure all ranks, all ages, all tempers, all passions of mere humanity, but extended its powers beyond the bounds of time and space, and seemed to render visible to mortal eyes the secrets of the invisible world. We may, perhaps, form the best guess of the feelings of Shakespeare's contemporary audience, by recollecting the emotions of any rural friend of rough, but sound sense, and ardent feelings, whom we have had the good fortune to conduct to a theatre for the first time in his life. It may be well imagined, that such a spectator thinks little of the three dramatic unities, of which Aristotle says so little, and his commentators and followers talk so much; and that the poet and the performers have that enviable influence over his imagination, which transports him from place to place at pleasure; crowds years into the course of hours, and interests him in the business of each scene, however disconnected from the others. His eyes are rivetted to the stage, his ears drink in the accents of the speakers, and he experiences in his mature age what we have all felt in childhood—a sort of doubt whether the beings and business of the scene be real or fictitious. In this state of delightful fascination, Shakespeare and the gigantic dramatic champions of his age, found the British public at large; and how they availed themselves of the advantages which so favourable a temper afforded them, their works will show so long as the language of Britain continues to be read. It is true that the enthusiastic glow of the public admiration, like the rays of a tropical sun darted upon a rich soil, called up in profusion weeds as well as flowers; and that, spoiled in some degree by the indulgent acceptation which attended their efforts, even our most admired writers of Elizabeth's age not unfrequently exceeded the bounds of critical nicety, and even of common taste and decorum. But these eccentricities were atoned for by a thousand beauties, to which, fettered by the laws of the classic drama, the authors would hardly have aspired, or aspiring, would hardly have attained. All of us know and feel how much the exercise of our powers, especially those which rest on keen feeling and self confidence, is dependent upon a favourable reception from those for whom they are put in action. Every one has observed how a cold brow can damp the brilliancy of wit, and fetter the flow of eloquence; and how both are induced to send forth sallies corresponding in strength and fire, upon being received by the kindred enthusiasm of those whom they have addressed. And thus, if we owe to the indiscriminate admiration with which the drama was at first received, the irregularities of the authors by whom it was practised, we also stand indebted to it, in all probability, for many of its beauties, which became of rare occurrence, when, by a natural, and indeed a necessary change, satiated admiration began to give way to other feelings.

When a child is tired of playing with a new toy, its next delight is to examine how it is constructed; and, in like manner, so soon as the first burst of public admiration is over with respect to any new mode of composition, the next impulse prompts us to ana-

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lyze and to criticise what was at first the subject of vague and indiscriminate wonder. In the first instance, the toy is generally broken to pieces; in the other, while the imagination of the authors is subjected to the rigid laws of criticism, the public generally lose in genius what they may gain in point of taste. The author who must calculate upon severe criticism, turns his thoughts more to avoid faults than to attain excellence; as he who is afraid to stumble must avoid rapid motion. The same process takes place in all the fine arts; their first productions are distinguished by boldness and irregularity; those which succeed by a better and more correct taste, but also by inferior and less original genius.

The original school founded by Shakespeare and Ben Jonson, continued by Massinger, Beaumont and Fletcher, Shirley, Ford, and others, whose compositions are distinguished by irregularity as well as genius, was closed by the breaking out of the great civil war in 1642. The stage had been the constant object of reprobation and abhorrence on the part of the puritans, and its professors had no favour to expect at their hands if victorious. We read, therefore, with interest, but without surprise, that almost all the actors took up arms in behalf of their old master King Charles, in whose service most of them perished. Robinson, a principal actor at the Blackfriars, was killed by Harrison in cold blood, and under the application of a text of scripture,—"Cursed is he that doeth the work of the Lord negligently." A few survivors endeavoured occasionally to practise their art in secrecy and obscurity, but were so frequently discovered, plundered and stripped by the soldiers, that "*Enter the red-coat, Exit hat and cloak,*" was too frequent a stage direction. Sir William Davenant endeavoured to evade the severe zealots of the time, by representing a sort of opera, said to have been the first drama in which moveable scenery was introduced upon the stage. Even the cavaliers of the more grave sort disapproved of the revival of these festive entertainments during the unstable and melancholy period of the interregnum. "I went," says the excellent Evelyn, in his *Diary*, 5th May 1658, "to see a new opera after the Italian way; in recitation, music, and scenes, much inferior to the Italian composure and magnificence; but it was prodigious that in such a time of public consternation, such a variety should be kept up or permitted, and being engaged with company, could not decently resist the going to see it, though my heart smote me for it." Davenant's theatrical enterprise, abhorred by the fanaticism of the one party, and ill adapted to the dejected circumstances of the other, was not probably very successful.

Second Period of the English Drama.

II. With royalty, the stage revived in England. But the theatres in the capital were limited to two, a restriction which has never since been extended. This was probably by the advice of Clarendon, who endeavoured, though vainly, to stem at all points the flood of idle gaiety and dissipation which broke in after the Restoration. The example of France might reconcile Charles to this exertion of royal authority. With this restoration of the drama, as well as of the crown, commences the second part of English dramatic history.

Charles II. had been accustomed to enjoy the foreign stage during his exile, and had taste enough to relish its beauties. It is probable, however, that his judgment was formed upon the French model, for few of the historical or romantic dramas were revived at the Restoration. So early as 26th November 1662, the *Diary* of Evelyn contains this entry: "I saw Hamlet, Prince of Denmark, played, but now the old plays began to disgust this refined age, since his Majesty has been so long abroad." Dryden, Howard, and others, who obtained possession of the stage, introduced, what was for some time called Heroic Plays, written in couplets, and turning upon the passions of love and honour. In the dialogue, these pieces resembled that of the French stage, where the actors declaim alternately in the best language, and in the finest thoughts which the poet can supply; but without much trace of natural passion or propriety of character. But though French in dialogue and sentiment, the heroic plays were English in noise and bustle, and the lack of truth and nature was supplied by trumpets and tempests, victories and processions. An entertainment of a character so forced and unnatural, was obviously of foreign growth, and flowed from the court. Dryden himself has assured us "that the favour which heroic plays had acquired upon the stage, was entirely owing to the countenance which they had received at court; and that the most eminent persons for wit and humour in the royal circle had so far honoured them, that they judged no way so fit as verse to entertain a noble audience, or express a noble passion." In these pieces the unities were not observed; but in place of the classical restrictions there were introduced certain romantic whimsical limitations of the dramatic art, which, had they been adopted, must soon have destroyed all its powers of pleasing. The characters were avowedly formed upon the model of the French romance, where honour was a sort of insane gasconading extravagance, and who seem to have made a vow never to speak or think of any thing but love; and that in language sometimes ingeniously metaphysical, sometimes puerile to silliness, sometimes mad even to raving, but always absurd, unnatural, and extravagant. In point of system it was stated, that a heroic play should be an imitation of a heroic poem. The laws of such compositions did not, it was said, dispense with those of the elder drama, but exalted them, and obliged the poet to draw all things as far above the ordinary proportion of the stage, as the stage itself is beyond the common words and actions of human life. The effects which a heroic play, constructed upon such an overstrained model, produced, is well described by Mrs Evelyn, wife of the author of that name already quoted, in a letter to *Mr Bohun*, written in 1671. "Since my last to you I have seen the *Siege of Grenada*, a play so full of ideas, that the most refined romance I ever read is not to compare with it. Love is made so pure, and valour so nice, that one would imagine it designed for an Utopia rather than our stage. I do

Introduction of the Heroic Plays.

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not quarrel with the poet, but admire one born in the decline of morality should be able to feign such exact virtue; and as poetic fiction has been instructive in former ages, I wish this the same event in ours. As to the strict law of comedy I dare not pretend to judge. Some think the division of the story not so well as if it could all have been comprehended in the day of action. Truth of history, exactness of time, possibilities of adventures, are niceties which the ancient critics might require, but those who have outdone them in fine notions may be allowed the liberty to express them their own way, and the present world is so enlightened that the old dramatique must bear no sway. This account perhaps is not enough to do *Mr Driden* right, yet is as much as you can expect from the leisure of one who has the care of a nursery." (See Evelyn's *Works*.) This ingenious lady felt what, overawed by the fashion of the moment, she has intimated rather than expressed; namely, that the heroic drama, notwithstanding the fine poetry of which it may be made the vehicle, was overstrained, fantastical, and unnatural.

In comedy, also, there was evinced, subsequent to the Restoration, a kindred desire of shining in dialogue, rather than attempting the humorous delineation of character of which Shakespeare, Jonson, and the earlier school, had set the example. The comic author no longer wrote to move the hearty laugh of a popular assembly, but to please a fashionable circle, "the men of wit and pleasure about town;" with whom wit and raillery is always more prevailing than humour. As in tragedy, therefore, the authors exhausted trope and figure, and reduced to logic the language of heroic passion; so in comedy, a succession of smart jests, which neither served to advance the action of the piece, or display the character of the speaker, were bandied to and fro upon the stage.

Heroic Plays superseded by Dramas of a more natural structure.

Satire is the appropriate corrective of extravagance in composition, and the *Rehearsal* of the Duke of Buckingham, though it can scarcely be termed a work of uncommon power, had yet the effect of holding up to public ridicule, the marked and obvious absurdities of the revived drama in both its branches. After the appearance of this satire, a taste too extravagant for long endurance was banished from the theatre; both tragedy and comedy retraced their steps, and approached more nearly to the field of human action, passion, and suffering; and down to the Revolution, a more natural style of drama occupied the stage. It was supported by men of the highest genius; who, but for one great leading error, might perhaps have succeeded in giving to the art its truest and most energetic character. The talents of Otway, in his scenes of passionate affection, rival, at least, and sometimes excel, those of Shakespeare. More tears have been shed, probably, for the sorrows of Belvidera and Monimia than for those of Juliet and Desdemona. The introduction of actresses upon the stage was scarce known before the Restoration, and it furnished the poets of the latter period with appropriate representatives for their female characters. This more happy degree of personification, as it greatly increased the perfection of the scene, must have animated in proportion the genius of the author. A marked improvement, therefore, may be traced in love scenes, and, indeed, in all those wherein female characters are introduced; that which was to be spoken by a fitting representative was, of course, written with more care, as it was acted with greater effect. This was an advantage, and a great one, possessed by the theatre succeeding the Restoration. Great dramatic force and vigour marked the dramatic compositions of this age. It was not, indeed, equal to that of Shakespeare, either in point of the talent called forth, or the quantity of original poetry given to the public; but Otway, and even Lee, notwithstanding his bombastic rant, possessed considerable knowledge of dramatic art and of stage-effect. Several plays of this period have kept possession of the stage; less, perhaps, on account of intrinsic merits, than because some of the broad errors of the earlier age had been removed, and a little more art had been introduced in the combination of the scenes, and disentanglement of the plot. The voice of criticism was frequently heard; the dramatic rules of the ancients were known and quoted; and though not recognized in their full extent, had nevertheless some influence in regulating the action of the drama.

Gross Immorality of the Drama.

In one heinous article, however, the poets of this age sinned at once against virtue, good taste, and decorum; and endangered, by the most profligate and shameless indecency, the cause of morality which has been often considered as nearly allied with that of the legitimate drama. In the first period of the British stage, the actors were men of decent character, and often acquired considerable independence. The women's parts were acted by boys. Hence, although there were too many instances of low and licentious dialogue, there were few of that abominable species which addresses itself not to the fancy but to the passions; and is seductive, instead of being ludicrous. Had Charles II. borrowed from the French monarch the severe etiquette of their court, when he introduced into England something resembling the style of their plays, he would have asserted what was due to his own dignity, and the cause of sound morals and good manners, by prohibiting this vulgar and degrading licence, which in itself was insulting to the presence of a king. It was, however, this prince's lot, in the regulation of his amusements, as well as in his state government, to neglect self-respectability. In his exile, he had been "merry, scandalous, and poor;" had been habituated to share familiarly coarse jests and loose pleasures with his dissolute companions; and, unfortunately, he saw no reason for disusing the licence to which he had accustomed himself, when it was equally destructive to his own character and to decorum. What had been merely coarse was, under his influence, rendered vicious and systematic impurity. Scenes, both passionate and humorous, were written in such a style, as if the authors had studied, whether the grave seduction of the heroic, or the broad infamy of the comic scenes, should contain the grossest insult to public decency. The female performers were of a character proper to utter whatever ribaldry the poet chose to put into

their mouths; and, as they practised what they taught, the King himself, and the leading courtiers, formed connections which gave the actresses a right to be saucy in their presence, and to reckon upon their countenance when practising in public the effrontery which marked their intercourse in private life. How much this shocked the real friends of Charles, is shown by its effects upon Evelyn, whose invaluable *Diary* we have already quoted: " This night was acted my Lord Broghill's tragedy called Mustapha, before their Majesties at court, at which I was present; though very seldom now going to the public theatres, for many reasons, as they are now abused to an atheistical liberty. Foul and indecent women now, and never till now, are permitted to appear and act, who, inflaming several young noblemen and gallants, became their misses and some their wives—witness the Earl of Oxford, Sir R. Howard, P. Rupert, the Earl of Dorset, and another greater person than any of them, who fell into their snares, to the reproach of their noble families, and ruin of both body and soul." He elsewhere repeatedly expresses his grief and disgust at the pollution and degeneracy of the stage. (Evelyn's *Works*, Vol. I. p. 392.) In a letter to Lord Cornbury (son of the great Clarendon) he thus expresses himself: " In the town of London, there are more wretched and indecent plays permitted, than in all the world besides;" and adds, shortly after, " If my Lord Chancellor would but be instrumental in reforming this one exorbitancy, it would gain both the King and his Lordship multitudes of blessings. You know, my Lord, that I (who have written plays, and am a scurvy poet, too, sometimes) am far from puritanisme; but I would have no reproach left our adversaries, in a theme which may so conveniently be reformed. Plays are now with us become a licentious exercise, and a vice, and neede severe cencors, that should look as well to their morality, as to their lines and numbers."— And, at the hazard of multiplying quotations, we cannot suppress the following:—1st March 1671. " I walked with him (the King) through St James's Park, to the garden, where I both heard and saw a very familiar discourse betwixt—(*i. e.* the King) and Mrs Nelly (Gwyn) as they called an impudent Comedian, she looking out of her terrace at the top of the wall, and —— [the King] standing in the green walk under it. I was heartily sorry at this scene."

The foul stain, so justly censured by a judge so competent, and so moderate as Evelyn, was like that of the leprosy in the Levitical Law, which sunk into and pervaded the very walls of the mansion; it became the leading characteristic of the English theatre, of its authors, and of its players. It was, however, especially in comedy, that this vice was most manifest; and, to say truth, were not the eyes of antiquaries, like the ears of confessors, free from being sullied by the impurities committed to them, the comedies of this period, as well as the comic scenes introduced to relieve the tragedies, are fitter for a brothel, than for the library of a man of letters.

It is a pity that we are under the necessity of drawing the character of the drama, at this age, from a feature so coarse and disgusting. Unquestionably, as the art in other respects made progress, it might, but for this circumstance, have reached an uncommon pitch of perfection. The comedies of Congreve contain probably more wit than was ever before embodied upon the stage; each word was a jest, and yet so characteristic, that the repartee of the servant is distinguished from that of the master; the jest of the coxcomb from that of the humorist or fine gentleman of the piece. Had not Sheridan lived in our own time, we could not have conceived the possibility of rivalling the comedies of Congreve. This distinguished author understood the laws of composition, and combined his intrigue with an art unusual on the British stage. Nor was he without his rivals, even where his eminence was most acknowledged. Vanburgh and Farquhar, inferior to Congreve in real wit, and falling into the next period, were, perhaps, his equals in the composition of acting plays. Like other powerful stimulants, the use of wit has its bounds, which Congreve is supposed sometimes to have exceeded. His dialogue keeps the attention too much upon the stretch, and, however, delightful in the closet, fatigues the mind during the action. When you are perpetually conscious that you lose something by the slightest interruption of your attention, whether by accident or absence of mind, it is a state of excitement too vivid and too constant to be altogether pleasant; and we feel it possible, that we might sometimes wish to exchange a companion of such brilliant powers, for one who would afford us more repose and relaxation.

The light, lively, but somewhat more meagre dialogue of the latter dramatists of the period, and of that which succeeded, was found sufficient to interest; yet was not so powerful as to fatigue the audience. Vanburgh and Farquhar seemed to have written more from the portraits of ordinary life; Congreve from the force of his own conception. The former, therefore, drew the characters of men and women as they found them; selected, united, and heightened for the purpose of effect; but without being enriched with any brilliancy foreign to their nature. But all the personages of Congreve have a glimpse of his own fire, and of his own acuteness. He could not entirely lay aside his quick powers of perception and reply, even when he painted a clown or a coxcomb; and all that can be objected, saving in a moral sense, to this great author, is, his having been too prodigal of his wit; a faculty used by most of his successors with rigid economy.

That personification of fantasy or whim, called characters of humour, which Ben Jonson introduced, was revived during this period. Shadwell, now an obscure name, endeavoured to found himself a reputation, by affecting to maintain the old school, and espousing the cause of Ben Jonson against Dryden and other innovators. But although there was considerable force of humour in some of his forgotten plays, it was Wycherly upon whom fell the burthen of upholding the standard of the Jonsonian school. The *Plain Dealer* is, indeed, imitated from Moliere; but the principal character has

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more the force of a real portrait, and is better contrasted with the perverse, bustling, masculine, pettyfogging, and litigious character of Widow Blackacker, than Alceste is with any of the characters in the *Misanthrope*. The other plays of this author are marked by the same strong, masculine, and forcible painting, which approaches more to the satire of Jonson, than to the ease of Vanburgh, the gaiety of Farquhar, or the wit of Congreve. Joining, however, the various merits of these authors, as belonging to this period, they form a galaxy of comic talent, scarce to be matched in any other age or country; and which is only obscured by those foul and impure mists, which their pens, like the raven wings of Sycorax, had brushed from fern and bog.

Morals repeatedly insulted, long demanded an avenger; and he arose in the person of Jeremy Collier. It is no disgrace to the memory of this virtuous and well-meaning man, that, to use the lawyer's phrase, he pleaded his cause too high; summoned, unnecessarily, to his aid the artillery with which the Christian fathers had fulminated against the Heathen Drama; and, pushing his arguments to extremity, directed it as well against the use as the abuse of the stage. Those who attempted to reply to him, availed themselves, indeed, of the weak parts of his arguments; but, upon the main points of impeachment, the poets stood self-convicted. Dryden made a manly and liberal submission, though not without some reflections upon the rudeness of his antagonist's attacks. " I shall say the less of Mr Collier, because in many things he has taxed me justly; and I have pleaded guilty to all thoughts and expressions of mine, which can be truly accused of obscenity, profaneness, or immorality, and retract them. If he be my enemy, let him triumph; if he be my friend, as I have given him no occasion to be otherwise, he will be glad of my repentance. It becomes me not to draw my pen in the defence of a bad cause, when I have so often drawn it for a good one. Yet it were not difficult to prove, that, in many places, he has perverted my meaning by his glosses, and interpreted my words into blasphemy and bawdry, of which they were not guilty; besides, that he is too much given to horse-play in his raillery, and comes from battle, like a dictator from the plough. I will not say, 'The zeal of God's house has eaten him up;' but, I am sure, it has devoured some part of his good manners and civility."—Congreve, less prudent, made an angry and petulant defence, yet tacitly admitted the charge brought against him, by retrenching, in the future editions of his plays, passages of grossness and profaneness, which the restless antiquary still detects in the early copies. And, on the whole, Collier's satire was attended with such salutary effects, that men started at the mass of impudence and filth, which had been gradually accumulated in the theatre, during the last reigns; and if the Augean stable was not sufficiently cleansed, the stream of public opinion was fairly directed against its conglomerated impurities. Since that period, indecency, that easy substitute for wit and pleasantry, has been gradually banished from the drama, where the conversation is now (according to Sheridan) at least always moral; if not entertaining.

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During the second period of the British Drama, great improvement was made in point of art. The principles of dramatic composition were more completely understood, and the poets themselves had written so much upon the subject, that, as Dryden somewhere complains, they had taught their audience the art of criticising their performances. They did not, however, so far surrender the liberties and immunities of their predecessors, as to receive laws from the French critics. The rules of the unities were no further adopted by Otway, Congreve, and the writers of their time, than their immediate purpose admitted. It was allowed, on all hands, that unnecessary and gross irregularities were to be avoided, but no precise rule was adopted; poets argued upon the subject according to caprice, and acted according to convenience. Gross and palpable extensions of time, and frequent changes of place, were avoided; and, unless in tragi-comedies, authors studied to combine the intrigue of their play into one distinct and progressive action. The genius by which this art was supported, was neither so general nor so profuse as that which decorated the preceding period. It was enough, however, to support the honour of the drama; and if the second period has produced fewer masterpieces of talent, it has exhibited more plays capable of being acted.

Third Period of the English Drama.

III. In the third period of dramatic history, the critics began to obtain an authority for which they had long struggled, and which might have proved fatal to the liberties of the stage. It is the great danger of criticism, when laying down abstract rules without reference to any example, that these regulations can only apply to the form, and never to the essence of the drama. They may assume, that the plot must be formed on a certain model, but they cannot teach the spirit which is to animate its progress. They cannot show how a passion should be painted, but they can tell to a moment when the curtain should be dropped. The misfortune is, that, while treating of these subordinate considerations, critics exalt them to an undue importance in their own minds and that of their scholars. What they carve out for their pupils is a mere dissection of a lifeless form; the genius which animated it escapes, as the principle of life glided from the scalpel of those anatomists who sought to detect it in the earlier days of that art. Rymer had, as early as 1688, discovered that our poetry of the last age was as rude as its architecture. " One cause thereof," he continues, " might be, that Aristotle's *Treatise of Poetry* has been so little studied amongst us; it was, perhaps, commented upon by all the great men in *Italy*, before we well knew (on this side of the Alps) that there was such a book in being." Accordingly, Rymer endeavours to establish what he calls the Rule of Reason over Fancy, in the contrivance and economy of a play. " Those who object to this subjugation," he observes, " are mere fanatics in poetry, and will never be saved by their good works." The species of reason, however, to which Rymer appeals, resembles, in its occult nature, that which lies hidden in

the depths of municipal law, and which is better known to the common class of mankind under the name of Authority. Because Aristotle assigns Pity and Terror as the objects of tragedy, Rymer resumes the proposition, that no other source of passion can be legitimate. To this he adds some arbitrary rules, of which it would be difficult to discover the rationale. It was the opinion, we are told, of the ancients, "that Comedy (whose province was humour and ridiculous matter only) was to represent worse than the truth, History to describe the truth, but Tragedy was to invent things better than the truth. Like good painters, they must design their images like the life, but yet better and more beautiful than the life. The malefactor of tragedy must be a better sort of malefactor than those that live in the present age: For an obdurate, impudent, and impenitent malefactor, can neither move compassion nor terror, nor be of any imaginable use in tragedy." It would be difficult to account for these definitions upon any logical principle, and impossible for an admirer of the drama to assent to a rule which would exclude from the stage Iago and Richard III. It is equally difficult to account for the *rationale* of the following dogmata: "If I mistake not, in poetry no woman is to kill a man, except her quality gives her the advantage above him; nor is a servant to kill his master; nor a private man, much less a subject, to kill a king, nor on the contrary. Poetical decency will not suffer death to be dealt to each other by such persons, whom the laws of duel allow not to enter the lists together." (Rymer's *View of the Tragedies of the Last Age.*) Though for these and similar critical conceits it would be difficult to find any just principle, nevertheless, Rymer, Dennis, and other critics who, mixing observations founded on sound judgment and taste, with others which rested merely upon dauntless assertion, or upon the opinions of Aristotle, began thereby to extend their authority, and produce a more than salutary influence upon the drama. It is true, that both of the aristarchs whom we have named were so ill advised as themselves to attempt to write plays, and thereby most effectually proved, that it was possible for a drama to be extremely regular, and, at the same time, intolerably dull. Gradually, however, their precepts, in despite of their example, gained influence over the stage. They laid down rules in which the audience were taught to regard the trade of a connoisseur as easy and soon learned; and the same quantity of technical jargon which, in the present day, constitutes a judge of painting, was, in the beginning of the eighteenth century, sufficient to elevate a Templar into a dramatic critic. The court of criticism, though self-constituted, was sufficiently formidable, since they possessed the power of executing their own decrees. Many authors made their submission; and, amongst others, Congreve humbled himself in the *Mourning Bride,* and Addison, with anxious and constitutional timidity, sacrificed to the unities in his celebrated tragedy of *Cato.* Being in form and essence rather a French than an English play, it is one of the few English tragedies which foreigners have admired. It was translated into Italian, and admired as a perfect model by Riccoboni, although his taste condemns the silly love intrigue. Its success was contagious. Southerne and Rowe may be considered as belonging to the same school; although the former admired Shakespeare, and the latter formed himself, in some degree, on the model of Otway. Translations of French tragedies became every day more frequent; and their diction and style of dialogue was imitated upon the British stage. The language of tragedy no longer expressed human passion, or intimated what the persons of the drama actually felt, but described and debated, alternately, what they ought to feel; and sounding sentences, and long similies, exhibiting an active fancy and a cold imagination, supplied at once the place of force and of pathos.

Unfavourable influence of Dramatic Criticism.

The line between comedy and tragedy was now strictly drawn. The latter was no longer permitted to show that strain of heroic humour which exhibits itself in the character of Falconbridge, Hotspur, and Henry V., as well as Mercutio. All was to be cold and solemn, and in the same key of dull, grave, state. Neither was comedy relieved by the touches of pathetic tenderness, and even sublimity, which are to be found in the romantic plays of the earlier period. To compensate the audience for the want of this beautiful variety of passion and feeling, Southern, as Otway had done before him, usually introduces a few scenes of an under-plot, containing the most wretched and indecent farce, which was so slightly and awkwardly dovetailed into the original tragedy, that they have since been cancelled as impertinent intrusions, without being so much as missed. Young, Thomson, and others who followed the same wordy and declamatory system of composition, contributed rather to sink than to exalt the character of the stage. The two first were both men of excellent genius, as their other writings have sufficiently testified; but, as dramatists, they wrought upon a false model, and their productions are of little value.

It is a remarkable instance of the decay of dramatic art at this period, that several of the principal authors of the time felt themselves at liberty to write imitations of old plays belonging to the original school, by way of adapting them to the taste of their own age. The *Fair Penitent* of Rowe is well known as a poor imitation of Massinger's *Fatal Dowry.* It does not greatly excel the original in the management and conduct of the piece; and, in every thing else, falls as far beneath it as the baldest translation can sink below the most spirited original.

It would appear that the players of this period had adopted a mode of acting correspondent to the poetical taste of the time. Declamation seems to have been more in fashion in the school of Booth and Betterton than that vivacity of action that exhibits at once with word, eye, and gesture, the immediate passion which it is the actor's part to express. "I cannot help," says Cibber, "in regard to truth, remembering the rude and riotous havock we made of all the late dramatic honours of the theatre! all became at once the spoil of ignorance, and self-conceit! Shakespeare was defaced, and tortured in every signal character; *Hamlet* and *Othello* lost, in one hour, all their good sense, their dignity, and fame; *Brutus* and *Cassius* became

noisy blusterers, with bold unmeaning eyes, mistaken sentiments, and turgid elocution!"—(Cibber's *Memoirs*.)

Lillo endeavours to enlarge the sphere of Tragedy.

A singular attempt to deviate from the prevailing taste in tragedy was made by Lillo, with the highly laudable purpose of enlarging the sphere of dramatic utility. He conceived that plays founded upon incidents of private life, might carry more immediate conviction to the mind of the hearers, and be the means of stifling more vices in the bud, than those founded on the more remote and grander events of history. Accordingly, he formed his plots from domestic crimes, and his characters never rose above the ranks of middle life. Lillo had many requisites for a tragedian; he understood, either from innate taste, or critical study, the advantage to be derived from a consistent fable; and, in the tragedy of the *Fatal Curiosity*, he has left the model of a plot, in which, without the help of any exterior circumstances, a train of events operating upon the characters of the dramatic persons, produce a conclusion at once the most dramatic and the most horrible that the imagination can conceive. Neither does it appear that, as a poet, Lillo was at all inferior to others of his age. He possessed a beautiful fancy; and much of his dialogue is as forcibly expressed as it is well conceived. On some occasions, however, he sinks below his subject; and on some, he appears to be dragged down to the nether sphere in which it is laid; and to become cold and creeping, as if depressed with the consciousness that he was writing upon a mean subject. *George Barnwell* never rises above an idle and profligate apprentice; Milwood's attractions are not beyond those of a very vulgar woman of the town; Thoroughgood, as his name expresses, is very worthy and very tiresome; and there is, positively, nothing to redeem the piece, excepting the interest arising from a tale of horror, and the supposed usefulness of the moral. The *Fatal Curiosity* is a play of a very different cast, and such as might have shaken the Grecian stage even during the reign of terror. But the powers of the poet prove unequal to the concluding horrors of his scene. Old Wilmot's character, as the needy man who had known better days, exhibits a mind naturally good, but prepared for acting evil, even by the evil which he has himself suffered, and opens in a manner which excites the highest interest and expectation. But Lillo was unable to sustain the character to the close. After discovering himself to be the murderer of his son, the old man falls into the common cant of the theatre; he talks about computing sands, increasing the noise of thunder, adding water to the sea, and fire to Etna, by way of describing the excess of his horror and remorse; and becomes as dully desperate, or as desperately dull, as any other despairing hero in the last scene of a fifth act.

Genteel Comedy.

During this third period of the drama, Comedy underwent several changes. The department called genteel comedy, where the persons as well as the foibles ridiculed, were derived chiefly from high life, assumed a separate and distinct existence from that which ransacked human nature at large for its subject. Like the tragedy of the period, this particular species of comedy was borrowed from the French. It was pleasing to the higher classes, because it lay within their own immediate circle, and turned upon the topics of gallantry, persiflage, affectation, and raillery. It was agreeable to the general audience, who imagined they were thereby admitted into the presence of their betters, and enjoyed their amusement at their expence. The *Careless Husband* of Cibber is, perhaps, the best English play on this model. The general fault to which they are all liable, is their tendency to lower the tone of moral feeling; and to familiarize men, in the middling, with the cold, heartless, and selfish system of profligate gallantry practised among the higher ranks. We are inclined to believe that, in a moral point of view, genteel comedy, as it has been usually written, is more prejudicial to public morals than plays, the tendency of which seems at first more grossly vicious. It is not so probable that the *Beggar's Opera* has sent any one from the two-shilling gallery to the highway, as that a youth entering upon the world, and hesitating between good and evil, may be determined to the worse course by the gay and seductive example of *Lovemore* or *Sir Charles Easy*. At any rate, the tenderness with which vices are shaded off into foibles, familiarizes them to the mind of the hearer, and gives a false colouring to those crimes which should be placed before the mind in their native deformity. But the heaviness of this class of plays, and the difficulty of finding adequate representatives for those characters which are really well drawn, are powerful antidotes to the evil which we complain of. That which is dully written, and awkwardly performed, will not find many imitators.

Comedy of Intrigue.

The genteel comedy being a plant of foreign growth, never obtained exclusive possession of the English stage, any more than court dresses have been adopted in our private societies. The comedy of intrigue, borrowed, perhaps, originally from the Spaniards, continued to be written and acted with success. Many of Cibber's pieces, of Centlivre's, and others, still retain their place on the stage. This is a species of comedy easily written, and seen with pleasure, though consisting chiefly of bustle and complicated incident; and requiring much co-operation of the dress-maker, scene painter, and carpenter. After all the bustle, however, of surprise and disguise, and squabble; after every trick is exhausted, and every stratagem played off, the writer too often finds himself in a labyrinth from which a natural mode of extrication seems altogether impossible. Hence the intrigue is huddled up at random; and the persons of the drama seem, as if by common consent, to abandon their dramatic character before throwing off their stage-dresses. The miser becomes generous; the peevish cynic good-humoured; the libertine virtuous; the coquette is reformed; the debauchee is reclaimed; all vices natural and habitual are abandoned by those most habitually addicted to them:—a marvellous reformation, which is brought about entirely from the consideration that the play must now be concluded. It was when pressed by this difficulty, that Fielding is said to have damned all fifth acts.

English Opera.

The eighteenth century, besides genteel comedy, and comedy of intrigue, gave rise to a new species

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of dramatic amusement. The Italian Opera had been introduced into this country at a great expence, and to the prejudice, as it was supposed, of the legitimate drama. Gay, in aiming at nothing beyond a parody of this fashionable entertainment, making it the vehicle of some political satire against Sir Robert Walpole's administration, unwittingly laid the foundation of the English opera. The popularity of his piece was unequalled; partly owing to its peculiar humour, partly to its novelty, partly to the success of the popular airs, which every body heard with delight, and partly to political motives. The moral tendency of the *Beggar's Opera* has been much questioned; although, in all probability, the number of highwaymen is not more increased by the example of Macheath, than that of murderers is diminished by the catastrophe of George Barnwell. Many years ago, however, an unhappy person, rather from a perverted and most misplaced ambition, than from the usual motives of want and desperation, chose, though in easy circumstances, and most respectably connected, to place himself at the head of a band of thieves and housebreakers, whose depredations he directed and shared. On the night on which they committed the crime for which he suffered, and when they were equipped for the expedition, he sung to his accomplices the chorus of the *Beggar's Opera*,—"Let us take to the road." But his confederates, professional thieves, and who pursued, from habit and education, the desperate practices which Mr B—— adopted from an adventurous spirit of profligate Quixotry, knew nothing at all of Gay or the *Beggar's Opera*; and in their several confessions and testimonies, only remembered something of a *flash-song*, about "turning lead to gold." This curious circumstance, while it tends to show that the drama may affect the weak part of a mind, predisposed to evil by a diseased imagination, proves the general truth of what Johnson asserts in the *Life of Gay*, that "highwaymen and housebreakers seldom mingle in any elegant diversions; nor is it possible for any one to imagine, that he may rob with safety, because he sees Macheath reprieved on the stage."

This play is now chiefly remarkable, as having given rise to the English Opera. In this pleasing entertainment, it is understood that the plot may be light and the characters superficial, provided that the music be good, and adapted to the situation, the scenes lively and possessed of comic force. Notwithstanding the subordinate nature of this species of composition, it approaches, perhaps, more closely to the ancient Grecian drama than any thing which retains possession of our stage. The subjects, indeed, are as totally different as the sublime from the light and the trivial. But, in the mixture of poetry and music, and in the frequent introduction of singing-characters unconnected with the business of the piece, and therefore somewhat allied to the chorus, the English Opera has some general points of resemblance with the Grecian tragedy. This species of dramatic writing was successfully practised by Bickerstaff, and has been honoured by the labours of Sheridan.

Fourth Period of the English Drama.

IV. With the fourth era of our dramatic history commenced a return to a better taste, introduced by the celebrated David Garrick. The imitations of French tragedy, and the tiresome uniformity of genteel comedy, were ill adapted to the display of his inimitable talent. And thus, if the last generation reaped many hours of high enjoyment from the performances of this great actor, the present is indebted to him for having led back the public taste to the dramas of Shakespeare.

Revival of the Plays of Shakespeare.

The plays of this great author had been altogether forgotten, or so much marred and disguised by interpolations and alterations, that he seems to have arisen on the British stage with the dignity of an antique statue disencumbered from the rubbish in which it had been enveloped since the decay of the art. But, although Garrick showed the world how the characters of Shakespeare might be acted, and so far paved the way for a future regeneration of the stage, no kindred spirit arose to imitate his tone of composition. His supremacy was universally acknowledged; but it seemed as if he was regarded as an object of adoration, not of imitation; and that authors were as much interdicted the treading his tragic path, as the entering his magic circle. It was not sufficiently remembered that the faults of Shakespeare, or rather of his age, are those into which no modern dramatist is likely to fall; and that he learned his beauties in the school of nature, which is ever open to all who profess the fine arts. Shakespeare may, indeed, be inimitable, but there are inferior degrees of excellence, which talent and study cannot fail to attain; and the statuary were much to blame who, in despair of modelling a Venus like that of Phidias, should set himself to imitate a Chinese doll. Yet such was the conduct of the dramatists of Britain long after the supremacy of Shakespeare had been acknowledged. He reigned a Grecian prince over Persian slaves; and they who adored him did not dare attempt to use his language.

Tragedy of this period.

The tragic muse appeared to linger behind the taste of the age, and still used the constrained and mincing measure which she had been taught in the French school. Hughes, Cumberland, and other men of talent, appeared in her service; but their model remained as imperfect as ever; and it was not till our own time that any bold efforts were made to restore to tragedy that truth and passion, without which, declamation is only rant and impertinence. Horace Walpole, however, showed what might be done by adopting a more manly and vigorous style of composition; and Home displayed the success of a more natural current of passion. The former chusing a theme not only totally unfit for representation, but from which the mind shrinks in private study, treated it as a man of genius, free from the trammels of habit and of pedantry. His characters in the *Mysterious Mother* do not belong to general classes, but have bold, true, and individual features; and the language approaches that of the first age of the English drama. The *Douglas* of Home is not recommended by this species of merit. In diction and character it does not rise above other productions of the period. But the interest turns upon a passion which finds a response in every bosom; for those who are too old

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for love, and too young for ambition, are all alike awake to the warmth and purity of maternal and filial affection. The scene of the recognition of Douglas's birth possesses a power over the affections, which, when supported by adequate representation, is scarce equalled in the circle of our drama. It is remarkable that the ingenious author was so partial to this theatrical situation, as to introduce it in several of his other tragedies.

Comedy of this period.

The comedy of the fourth period is chiefly remarkable for exhibiting *The Rivals* and the *School for Scandal*. Critics prefer the latter; while the general audience reap, perhaps, more pleasure from the former; the pleasantry being of a more general cast, the incident more complicated and varied, and the whole plot more interesting. In both these plays, the gentlemanlike ease of Farquhar is united with the wit of Congreve. Indeed, the wit of Sheridan, though equally brilliant with that of his celebrated predecessor, flows so easily, and is so happily elicited by the line of the dialogue, that, in admiring its sparkles, we never once observe the stroke of the flint which produces them. Wit and pleasanty seemed to be the natural atmosphere of this extraordinary man, whose history was at once so brilliant and so melancholy. Goldsmith was, perhaps, in relation to Sheridan what Vanburgh was to Congreve. His comedies turn on an extravagance of intrigue and disguise, and so far belong to the Spanish school. But the ease of his humorous dialogue, and the droll, yet true conception of the characters, made sufficient amends for an occasional stretch in point of probability. If all who draw on the spectators for indulgence, were equally prepared to compensate by a corresponding degree of pleasure, they would have little occasion to complain. The elder Colman's *Jealous Wife*, and some of his smaller pieces, are worthy, and it is no ordinary compliment, of being placed beside these masterpieces. We dare not rank Cumberland so high, although two or three of his numerous efforts retain possession of the stage. *The Wheel of Fortune* was certainly one of the best acting plays of its time, but it was perhaps chiefly on account of the admirable representative which the principal character found in Mr John Kemble.

The plays of Foote, the modern Aristophanes, who ventured, by his powers of mimicking the mind as well as the external habits, to bring living persons on the stage, belong to this period, and make a remarkable part of its dramatic history. But we need not dwell upon it. Foote was an unprincipled satirist; and while he affected to be the terror of vice and folly, was only anxious to extort forbearance-money from the timid, or to fill his theatre at the indiscriminate expence of friends and enemies, virtuous or vicious, who presented foibles capable of being turned into ridicule. It is a just punishment of this course of writing, that Foote's plays, though abounding in comic and humorous dialogue, have died with the parties whom he ridiculed. When they lost the zest of personality, their popularity, in spite of much intrinsic merit, fell into utter decay.

Meantime dramatic composition of the higher class seemed declining. Garrick in our fathers' time, Mrs Siddons in ours, could neither of them extract from their literary admirers any spark of congenial fire. No part written for either of these astonishing performers has survived the transient popularity which their talents could give to almost anything. The truth seems to be, that the French model had been wrought upon till it was altogether worn out; and a new impulse from some other quarter—a fresh turning up of the soil, and awakening of its latent energies by a new mode of culture, was become absolutely necessary to the renovation of our dramatic literature. England was destined to receive this impulse from Germany, where literature was in the first luxuriant glow of vegetation, with all its crop of flowers and weeds rushing up together. There was good and evil in the importation derived from this superabundant source. But the evil was of a nature so contrary to that which had long palsied our dramatic literature, that, like the hot poison mingling with the cold, it may in the issue bring us nearer to a state of health.

The Drama receives a new impulse from Germany.

The affectation of Frederic II. of Prussia, and of other German princes, for a time suppressed the native literature, and borrowed their men of letters from France, as well as their hair-dressers,—their dramas as well as their dressed dishes. The continental courts, therefore, had no share in forming the national drama. To the highest circle in every nation, that of France will be most acceptable, not only on account of its strict propriety and conformity to *les convenances*, but also as securing them against the risk of hearing bold and offensive truths uttered in the presence of the sovereign and the subject. But the bold, frank, cordial, and rough character of the German people at large, did not relish the style of the French tragedies translated for their stage; and this cannot be wondered at, when the wide difference between the nations is considered.

The natural character of the Germans is diametrically opposite to that of the French. The latter are light almost to frivolity, quick in seeing points of ridicule, slowly awakened to those of feeling. The Germans are of an abstracted, grave, and somewhat heavy temper, less alive to the ridiculous; more easily moved by an appeal to the passions. That which moves a Frenchman to laughter, affects a German with sorrow or indignation; and in that which touches the German as a source of the sublime or pathetic, the quick-witted Frenchman sees only subject of laughter. In their theatres the Frenchman comes to judge, to exercise his critical faculties, and to apply the rules which he has learned, fundamentally or by rote, to the performance of the night. A German, on the contrary, expects to receive that violent excitation which is most pleasing to his imaginative and somewhat phlegmatic character. While the Frenchman judges of the form and shape of the play; the observance of the unities, and the denouement of the plot, the German demands the powerful contrast of character and passion,—the sublime in tragedy and the grotesque in comedy. The former may be called the formalist of dramatic criticism, keeping his eye chiefly on its exterior shape and regular form; the latter is the fanatic, who, disregarding forms, requires a deep and powerful tone of passion and of sentiment, and

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is often content to surrender his feelings to inadequate motives.

General Character of the German Drama.

From the different temper of the nations, the merits and faults of their national theatres became diametrically opposed to each other. The French author is obliged to confine himself, as we have already observed, within the circle long since described by Aristotle. He must attend to all the decorum of the scene, and conform to every regulation, whether rational or arbitrary, which has been entailed on the stage since the days of Corneille. He must never so far yield to feeling, as to lose sight of grace and dignity. He must never venture so far in quest of the sublime, as to run the risk of moving the risible faculties of an audience, so much alive to the ludicrous, that they will often find or make it in what is to others the source of the grand or the terrible. The Germans, on the contrary, have never subjected their poets to any arbitrary forms. The division of the empire into so many independent states, has prevented the ascendancy of any general system of criticism; and their national literature was not much cultivated, until the time when such authority had become generally unpopular. Lessing had attacked the whole French theatrical system in his *Dramaturgie* with the most bitter raillery. Schiller brought forward his splendid dramas of Romance and of History. Goethe crowded the stage with the heroes of ancient German chivalry. No means of exciting emotion were condemned as irregular, providing emotion was actually excited. And there can be no doubt that the licence thus given to the poet,—the willingness with which the audience submitted to the most extravagant postulates on their part, left them at liberty to exert the full efforts of their genius.

Lessing, Schiller, and Goethe, became at once the fathers and the masters of the German theatre; and it must be objected to these great men, that, in the abundance of their dramatic talent, they sometimes forgot that their pieces, in order to be acted, must be adapted to the capabilities of a theatre; and thus wrote plays altogether incapable of being represented. Their writings, although affording many high examples of poetry and passion, are marked with faults which the exaggeration of their followers has often carried into total extravagance. The plays of Chivalry and of History were followed by an inundation of imitations, in which, according to Schlegel, "there was nothing historical but the names and external circumstances; nothing chivalrous but the helmets, bucklers, and swords; and nothing of old German honesty but the supposed rudeness. The sentiments were as modern as they were vulgar; from chivalry pieces, they were converted into cavalry plays, which certainly deserve to be acted by horses rather than men." (Schlegel *on the Drama*.)

It is not the extravagance of the apparatus alone, but exaggeration of character and sentiment, which have been justly ascribed as faults to the German school. The authors appear to have introduced too harshly, brilliant lights and deep shadows; the tumid is too often substituted for the sublime; and faculties and dispositions the most opposed to each other, are sometimes described as existing in the same person.

In German comedy the same faults predominate to a greater degree. The pathetic comedy, which might be rather called domestic tragedy, became, unfortunately, very popular in Germany; and found a champion in Kotzebue, who carried its conquests over all the continent. The most obvious fault of this species of composition is, the demoralizing falsehood of the pictures which it offers to us. The vicious are frequently presented as objects less of censure than of sympathy; sometimes they are selected as objects of imitation and praise. There is an affectation of attributing noble and virtuous sentiments, to the persons least qualified by habit or education to entertain them; and of describing the higher and better educated classes, as uniformly deficient in those feelings of liberality, generosity, and honour, which may be considered as proper to their situation in life. This contrast may be true in particular instances, and being used sparingly, might afford a good moral lesson; but in spite of truth and probability it has been assumed, upon all occasions, by these authors, as the groundwork of a sort of intellectual jacobinism; consisting, as Mr Coleridge has well expressed it, "in the confusion and subversion of the natural order of things, their causes and their effects; in the excitement of surprise, by representing the qualities of liberality, refined feeling, and a nice sense of honour, in persons and in classes of life where experience teaches us least to expect them; and in rewarding with all the sympathies that are the dues of virtue, those criminals whom law, reason, and religion, have excommunicated from our esteem."

The German taste was introduced upon the English theatre within these twenty years. But the better productions of her stage have never been made known to us; for, by some unfortunate chance, the wretched pieces of Kotzebue have found a readier acceptance, or more willing translators, than the sublimity of Goethe, the romantic strength of Schiller, or the deep tragic pathos of Lessing. They have tended, however (wretched as the model is), to introduce on our stage a degree of sentiment, and awaken among the audience a strain of sensibility to which we were strangers.

George Coleman's comedy of *John Bull* is by far the best effort of our late comic drama. The scenes of broad humour are executed in the best possible taste; and the whimsical, yet native characters, reflect the manners of real life. The sentimental parts, although one of them includes a finely wrought up scene of paternal distress, partake of the *falsetto* of German pathos. But the piece is both humorous and affecting; and we readily excuse its obvious imperfections, in consideration of its exciting our laughter and our tears.

Joanna Baillie.

While the British stage received a new impulse from a country whose literature had hitherto scarce been known to exist, she was enriched by productions of the richest native genius. A retired female, thinking and writing in solitude, presented to her coun-

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trymen the means of regaining the true and manly tone of national tragedy. She has traced its foundation to that strong instinctive and sympathetic curiosity, which tempts men to look into the bosoms of their fellow creatures, and to seek, in the distresses or emotions of others, the parallel of their own passions. She has built on the foundations which she laid bare, and illustrated her precepts by examples, which will long be an honour to the age in which they were produced, and admired;—yet its disgrace, when it is considered that they have been barred their legitimate sphere of influence upon the public taste.

Maturin, Coleridge, and others.

Besides this gifted person, the names of Coleridge, of Maturin, and other men of talents, throng upon our recollection; and there is one who, to judge from the dramatic sketch he has given us in *Manfred*, must be considered as a match for Æschylus, even in his sublimest moods of horror. It is no part of our plan, however, to enter upon the criticism of our contemporaries. Suffice it to say, that the age has no reason to apprehend any decay of dramatic talent.

Neither can our actors be supposed inadequate to the representation of such pieces of dramatic art, as we judge our authors capable of producing. We have lost Mrs Siddons and John Kemble, but we still possess Kean, Young, and Miss O'Neil; and the stage has to boast other tragic performers of merit. In comedy, perhaps, it was never more strong. In point of scenery and decoration, our theatres are so amply provided, that they may rather seem to exceed than to fall short of what is required to form a classical exhibition.

Bad consequences of the Monopaly possessed by the London Theatres.

Where, then, are we to look for that unfortunate counterbalance, which confessedly depresses the national drama in despite of the advantages we have enumerated? We apprehend it will be found in the monopoly possessed by two large establishments, which, unhappily for the progress of national taste, and, it is said, without any equivalent advantage to the proprietors, now enjoy the exclusive privilege of dramatic representation. It must be distinctly understood, that we attribute these disadvantages to the *system* itself, and by no means charge them upon those who have the administration of either theatre. The proprietors have a right to enjoy what the law invests in them; and the managers have probably discharged their duty to the public as honourably as circumstances would admit of; but the system has led into errors which affect public taste, and even public morals. We shall briefly consider it as it influences, 1*st*, the mode of representation; 2*dly*, the theatrical authors and performers; and, 3*dly*, the quality and composition of the audience.

The *first* inconvenience arises from the great size of the theatres, which has rendered them unfit for the legitimate purposes of the drama. The persons of the performers are, in these huge circles, so much diminished, that nothing short of the mask and buskin could render them distinctly visible to the audience. Show and machinery have, therefore, usurped the place of tragic poetry; and the author is compelled to address himself to the eyes, not to the understanding or feelings of the spectators. This is of itself a gross error. Every thing beyond correct costume and theatrical decorum is foreign to the legitimate purposes of the drama, as tending to divide the attention of the audience; and the rivalry of the scene-painter and the carpenter cannot be very flattering to any author or actor of genius. Besides, all attempts at decoration, beyond what the decorum of the piece requires, must end in paltry puppet-show exhibition. The talents of the scene-painter and mechanist cannot, owing to the very nature of the stage, make battles, sieges, &c. any thing but objects of ridicule. Thus we have enlarged our theatres, so as to destroy the effect of acting, without carrying to any perfection that of pantomime and dumb show.

Secondly, The monopoly of the two large theatres has operated unfavourably both upon theatrical writers and performers. The former have been, in many instances, if not absolutely excluded from the scene, yet deterred from approaching it, in the same manner as men avoid attempting to pass through a narrow wicket, which is perpetually thronged by an importunate crowd. Allowing the managers of these two theatres, judging in the first and in the last resort, to be possessed of the full discrimination necessary to a task so difficult—supposing them to be at all times alike free from partiality and from prejudice—still the number of plays thrust upon their hands must prevent their doing equal justice to all; and must frequently deter a man of real talents, either from pride or modesty, from entering a competition, clogged with delay, solicitation, and other circumstances, "*haud subeunda ingenio suo*." It is unnecessary to add, that increasing the number of theatres, and diminishing their size, would naturally tend to excite a competition among the managers, whose interest it is to make experiments on the public taste; and that this would infallibly secure any piece of reasonable promise a fair opportunity of being represented. It is by such a competition that genius is discovered; it is thus that horticulturists raise whole beds of common flowers, for the chance of finding among them one of those rare varieties which are the boast of their art.

The exclusive privilege of the regular London theatres is equally, or in a greater degree, detrimental to the performer; for it is with difficulty that he fights his way to a London engagement, and when once received, he is too often retained for the mere purpose of being laid aside or *shelfed*, as it is technically called;—rendered, that is, a weekly burden upon the pay-list of the theatre, without being produced above four or five times in the season to exhibit his talents. Into this system the managers are forced from the necessity of their situation, which compels them to enlist in their service every performer who seems to possess buds of genius, although it ends in their being so crowded together that they have no room to blossom. In fact, many a man of talent thus brought from the active exercise of a profession, to be paid for remaining inactive in obscurity in London, and supported by what seems little short of eleemosynary bounty, either becomes careless of his business or disgusted with it; and, at any rate, stagnates in that mediocrity to which want of exercise alone will often condemn talent.

Thirdly, and especially, the magnitude of these

theatres has occasioned them to be destined to company so scandalous, that persons not very nice in their taste of society, must yet exclaim against the abuse as a national nuisance. We are aware of the impossibility of excluding a certain description of females from public places in a corrupted metropolis like London; but in theatres of moderate size, frequented by the better class, these unfortunate persons would feel themselves compelled to wear a mask at least of decency. In the present theatres of London, the best part of the house is openly and avowedly set off for their reception; and no part of it that is open to the public at large is free from their intrusion, or at least from the open display of the disgusting improprieties to which their neighbourhood gives rise. And these houses, raised at an immense expence, are so ingeniously misconstructed, that, in the private boxes you see too little of the play, and, in the public boxes, greatly too much of a certain description of the company. No man of delicacy would wish the female part of his family to be exposed to such scenes; no man of sense would wish to put youth, of the male sex, in the way of such temptation. This evil, if not altogether arising from the large size of the theatres, has been so incalculably increased by it, that, unless in the case of strong attraction, prostitutes and their admirers usually form the principal part of the audience. We censure, and with justice, the corruption of morals in Paris. But in no public place in that metropolis is vice permitted to bear so open and audacious a front as in the theatres of London. Barefaced vice is never permitted to insult decency.—Those who seek it must go to the haunts to which it is limited. In London, if we would enjoy our most classical public amusement, we are braved by her on the very threshold.

We notice these evils, without pretending to point out the remedy. If, however, it were possible so to arrange interests, that the patents of the present theatres should cover four, or even six, of smaller size, dedicated to the same purpose, we conceive that more good actors would be found, and more good plays written; and, as a necessary consequence, that good society would attend the theatre in sufficient numbers to enforce respect to decency. The access to the stage would be rendered easy to both authors and actors; and although this might give scope to some rant, and false taste, it could not fail to call forth much excellence, that must otherwise remain latent or repressed. The theatres would be relieved of the heavy expence at present incurred, in paying performers who do not play; and in each maintaining three theatrical corps for the separate purposes of tragedy, comedy, and musical pieces; only one of which can be productive labourers on the same evening, though all must be supported and paid. According to our more thrifty plan, each of these companies would be earning at the same time the fruits of their professional industry. The hours of representation, in one or more of these theatres, might be rendered more convenient to those in high life, while the middling classes might enjoy a rational and classical entertainment after the business of the day.

Such an arrangement might, indeed, be objected to, by those who entertain a holy horror of the very name of a theatre; and who imagine impiety and blasphemy are inseparable from the drama. We have no room left to argue with such persons; or we might endeavour to prove, that the dramatic art is in itself as capable of being directed either to right or wrong purposes, as the art of printing. It is true, that even after a play has been formed upon the most virtuous model, the man who is engaged in the duties of religion will be better employed than he who is seated in a theatre, and listening to it. To those abstracted and enrapt spirits, who feel, or suppose, themselves capable of remaining constantly involved in heavenly thoughts any sublunary amusement may justly seem frivolous. But the mass of mankind are not so framed. The Supreme Being, who claimed the seventh day as his own, alloted the other six days of the week for purposes merely human. When the necessity of daily labour is removed, and the call of social duty fulfilled, that of moderate and timely amusement claims its place, as a want inherent in our nature. To relieve this want, and fill up the mental vacancy, games are devised, books are written, music is composed, spectacles and plays are invented and exhibited. And if these last have a moral and virtuous tendency; if the sentiment expressed tend to rouse our love of what is noble, and our contempt of what is mean; if they unite hundreds in a sympathetic admiration of virtue, abhorrence of vice, or derision of folly; it will remain to be shown how far the spectator is more criminally engaged, than if he had passed the evening in the idle gossip of society; in the feverish pursuits of ambition; or in the unsated and insatiable struggle after gain—the graver employments of the present life, but equally unconnected with our existence hereafter. (N.N.)

DREDGING is a term used to express an important operation in the practice of the engineer, that of removing mud and other deposited matters from the bed of rivers, canals, harbours, and basins.

Of the Process of Silting.

In describing the several methods by which dredging has been successfully employed for preserving the necessary depth of water in our harbours and tracks of inland navigation, it is not our intention to enter minutely into geological discussions regarding the deposition of silt or mud; but we cannot allow the process of silting to pass without at

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least hinting at the cause of such depositions. If we consider the tendency to waste and decay in the higher lands from the agency of *moisture*, *heat*, and *frost*, we shall find that every *rill* of water carries along with it a portion of separated matter; and these rills being so many tributary streams to the great rivers forming the drainage of vast tracts of country, we need not be surprised to find the beds of such rivers as the Thames, the Humber, the Tay, and the Clyde, &c. much incumbered in the central parts by numerous sand-banks, while their margins are skirted with the finer or more minute particles called silt and mud. Nor can we avoid noticing this marked difference in the separation of the deposited matters at the mouths of rivers which flow with a very gentle current towards the sea. From the greater specific gravity of the salt water, it is found to preserve its course up the respective rivers, according to the rise of the tide, in a distinct stratum under the fresh water. A considerable proportion of the heavier matters, as gravel and sand, may thus be conceived to be arrested in their progress, whereas the lighter particles, floating at or near the surface, are either borne along with the stream into the ocean, or, by getting into the eddy waters, formed by the projecting obstacles along the banks of the respective rivers, are, in this manner, allowed to be deposited in the form of *silt*, *sleek*, or *mud*.

The more ponderable matters, accordingly, accumulate in the form of sand-banks and small islets in the central parts of the stream, while all the creeks and sinuosities on the margin are silted up, and too often render the connecting harbours and shipping-places so shallow as to be unfit for the purposes of floating ships of burden. To such a degree has this been experienced in some situations on our shores, as for example at Sandwich in Kent, that that ancient sea-port is left almost in the state of an *inland town*. Great importance is therefore justly attached to such means as may be instrumental in preventing so great an evil; and we shall endeavour to direct the attention of our readers to the different modes of dredging, by treating the subject under the following heads, viz. the Scouring Basin, the Harrow, &c. the Spoon Apparatus, and the Bucket dredging machine, worked by the power of men, by horses, and by steam.

Scouring Basin.

The *Scouring Basin* is a water-tight compartment of a harbour, furnished with sluices, and set apart for containing a quantity of tidal or river water, to be run off at low tides for scouring or floating away the stuff which may have been loosened in the process of dredging; or in situations where the command of *head-water* is considerable. It is used for cleansing the bottom and *bar* of *harbours*, without the assistance of any dredging apparatus; indeed, it is only in conjunction with such basins, natural or artificial, that the several modes of dredging, simply by loosing the stuff, can be rendered effectually or permanently useful. All harbours left in a state of dryness every tide, at low water, ought, if possible, to be furnished with a scouring basin, especially those situated at the embouchure or upon the banks of rivers, where the deposition of mud is most apt to take place. We cannot, perhaps, illustrate this better than by referring to the harbour of Montrose in Forfarshire, where the great natural basin connected with that harbour is flooded every tide by the waters of the ocean, to the extent of about five square miles, and has been estimated to contain about fifty-five millions of cubic yards of backwater, which produces so great a current, that the shifting sand-bank called the Annet, is prevented from being thrown across the mouth or entrance of that harbour in gales of wind from the eastward. By this means a great body of water is kept passing through the comparatively small entrance of the harbour, which not only keeps the navigation open, but is sufficient to preserve it of considerable depth, even at the lowest ebbs of the tide. The same observation is strictly applicable to the entrance of all great rivers or estuaries, where the navigation can only be preserved by a strong current of water. We accordingly find that the most eminent engineers, both of our own country and of France, have introduced scouring basins into their designs of *tide harbours*. Mr Smeaton constructed a basin of this kind at Ramsgate, where the silt of the outer harbour is dredged or loosened, and raked into the tracks or courses of the water issuing from the sluices in the scouring basin; by which a considerable portion of the stuff is carried out of the harbour into deep water. It is, however, to be regretted that the very circumscribed position of this harbour prevented that eminent engineer from enlarging this basin sufficiently; so that the good effects of this design have never, it is believed, been fully experienced. In extensive chains or plans of wet docks, much use may be made of this mode of scouring or floating away mud, by opening numerous sluices from one dock into another; and also by taking the advantage of such a command of *head water* for clearing the outer harbour, or receiving basin, by a judicious and well-directed system of sluices.

Dredge Harrow, &c.

The *Harrow*, and even the *common plough*, and also a kind of dredging-frame, made of timber and plate iron, like a box without bottom or top, is chiefly used for loosening or dragging loose stuff, and bringing it within reach of removal, by the waters of the scouring basin, the spade, and barrow. These, and other implements of less note, have been used with good effect in navigable rivers and harbours. Such modes are much practised in Holland, upon the extensive flats at the entrance of the great navigable rivers of that country, in connection with the operation of the sluices and strong currents issuing from their extensive basins and canals. In Great Britain, dredging is now almost exclusively confined to the *spoon* and *bucket* apparatus, for lifting and removing the stuff. But, in the improvement of the navigation of the river Clyde, even these have now, in a good measure, been laid aside by the enlightened trustees; having given way to the natural and more successful operations of narrowing the channel and confining the current, which has at length produced the depth of about nine feet, instead of five feet, as formerly; from which the trade and commerce of the city of Glasgow derive the most decided advantages.

Spoon Dredging Boat.

The spoon dredging-boat has been long, and is, indeed, still much used by the Dutch, with whom it, in all probability, originated. It is also at this moment more extensively employed on the Thames than the bucket-machine, or any other contrivance for lifting ballast, and improving the navigation of that river. Referring to Plate LXXIII, and to the figure on it marked *Spoon Dredging Boat*, the reader will at once comprehend this simple apparatus. The boat varies in size according to the situation in which it is to be used; but is generally from twenty to sixty tons burden. These boats are built so as to float upon an easy draught of water; they are sometimes *flush-decked*, and carry their cargo upon deck, but the greater part, and especially the larger sizes, are in the state of open boats, or have a kind of inner sole or floor. When the excavated matters are not to be employed in banking or for ballast, a convenient mode of getting quit of them is to have an aperture or open in the bottom, by which the stuff is afterwards dropped into deep water, in the manner represented in one of the compartments of the boat in the diagram.

The spoon apparatus consists of a strong ring or hoop of malleable iron, about six or seven feet in circumference, properly formed for making an impression upon the soft and muddy ground. To this ring a large bag is strongly attached with thongs, which are sometimes made of *bullock's-hide,* but more generally of tanned leather. The bag is perforated with a number of small holes for allowing the water to drain off, and its capacity may be about four or five cubic feet. A long pole or handle is attached to the spoon, and a rope to the bottom of the bag for directing their position at the commencement of each operation. The pole or handle varies in length and thickness according to the depth of water, from fifteen to thirty feet. This apparatus is generally worked with a wheel and pinion, or winch, and the chain or rope is brought from the spoon to the winch through a block suspended from a small crane for bearing the spoon and its contents to the side of the boat, and bringing it over the gunwale to be emptied into the boat. The purchase rope is led upon deck by a snatch block in the proper direction for the barrel of the winch. These dredging boats, when placed for work, are moored at head and stern with *guy ropes* for shifting their birth at pleasure. They are managed and wrought with from two to four men, who with this simple apparatus can lift from twenty to sixty tons in one tide, at the depth of about two and a half or three fathoms, when the ground is somewhat loose, and favourable for the operation.

In Holland and Flanders, the spoon apparatus is much used in deepening the extensive tracts of canal, where the labour is more easily performed than on the Thames, from the absence of tide or current, and from the more manageable nature of the stuff at the bottom. There the excavated matters are very generally of a mossy description, which, after being compressed in moulds, is used as *turf-fuel.* On the Thames, this operation is conducted upon a great scale, and in the most systematic manner, under the immediate direction of the Trinity Board of London; and the stuff dredged and brought up from the bottom, consisting chiefly of mud and gravel, is not only useful for deepening and improving the navigation, but is sold to good advantage as ballast to the shipping of the port of London, particularly to the colliers; and to such an extent is this process carried on, that the *Ballast Hills* of Shields and Newcastle, which form no small curiosity from their vast extent, have been chiefly brought from the Thames.

Dredging.

Bucket Dredging Machine.

In proportion as the commerce of a country extends, its shipping increase in dimensions, and a greater depth of water is consequently required to float them; and greater difficulty and expence are accordingly experienced in constructing the necessary harbours along the coast, and in preserving a sufficient depth of water. To effect the objects in view, recourse has been had to various means, such as extending piers and breakwaters, together with the apparatus above described. These have been succeeded by a still more powerful apparatus, termed the *Bucket Dredging Machine.*

This powerful engine is said to have been first worked by men only; when the principles on which it acts were more fully ascertained, horses were employed, but it is now generally worked by the power of steam. Different situations are found to require peculiar modes of application. Thus we find, that at the port of Greenock, on the Clyde, after using one of these machines with horses working in a covered *gin-tract*, or circular path in the boat, it is now found to be more suitable and expedient to resort to the use of manual labour, applied by crane-work, with a wheel and pinion. Perhaps in all situations where fuel is very expensive, and where the work is not of sufficient extent for the full and ample employment of a steam-engine, it will be found better to have recourse to manual labour than to the power of horses, which is applied under many disadvantages on board of a boat of this kind, as experience has shown in the Clyde. Indeed, the only question with us is, whether, in cases of this kind, it would not be much better to use the spoon apparatus.

The bucket dredging-machine is the same in principle, whether the power applied be that of men, horses, or steam. We shall, however, in our description, refer to a vessel with a steam-engine for working the buckets, Plate LXXIII. We hope that this apparatus, with the connecting diagrams, will appear sufficiently obvious, without the necessity of having recourse to numerous alphabetical references, which often tend to distract the general reader, without being useful or necessary to those professionally instructed, who must, in their operations, proceed upon experience, and a more precise knowledge of the subject than can be conveyed in an article of this limited extent. We, therefore, deem it unnecessary to give references to the parts of the vessel or dredging machinery, consisting of the moveable frame and revolving buckets for lifting the deposited matters from the bottom, and the mode of discharging the stuff into the receiving boats; as this will be easily understood upon a simple inspection of the plate.

In describing the operation of dredging with the bucket-machine, we may suppose the vessel brought to the position in which she is intended to work,

where she is moored by the head and stern, and provided with the necessary crane-work and ropes for shifting her birth at the discretion of the boatmen. The bucket-frame, which consists of two beams of timber, is supported on a rod of iron with shores of wood; on these beams the full buckets move upon iron rollers fixed to the timber, while the empty buckets and endless chain form a curve in descending to the bottom, which is essential to the manner in which the buckets are respectively intended to touch the ground. The bucket-frame, so constructed, is then lowered with proper precaution till the empty buckets come in contact with the mud, and, according to the tenacity of the stuff, a greater or less impression is made by the buckets on the ground. The operation of lowering and raising the frame is usually performed by a piece of crane-work, distinct from the machinery of the steam-engine: but a considerable improvement has been made in the dredging-machine lately constructed for deepening the harbour of Dundee, in which the bucket-frame is lowered and raised with great regularity by a power taken from the steam-engine; as will be seen by tracing the line of the purchase-chain from the lower part of the bucket-frame to the machinery of the engine. Things being in this state of preparation, the buckets are ranged on the frame and put in motion by the power of men, horses, or steam.

The reader may next attend to the direction of the buckets, as delineated on the plate, from the lower point, where they are shown touching the ground, to the upper extremity of the frame, where the stuff is tilted into a kind of trough. This operation will readily be understood by directing our attention to the *crown* or upper-wheel of the train of machinery, connected with the steam-engine; which is placed upon the *same axle* with the *upper-tumbler* of the bucket-frame with which the train of buckets is made to revolve by means of an *endless chain*. The buckets at the lower end of the frame are continually filling, while those at the upper extremity are, at the same time, emptied. The tumbler, buckets, and endless chain, form very important parts of this apparatus, and we have, therefore, given separate views of these, upon an enlarged scale, in the connecting diagrams on the plate, from which the general dimensions may be ascertained. Instead of a cylindrical barrel, the tumbler is necessarily formed into a polygonal figure by bars of iron, to which the links of the endless chain are exactly fitted; and in revolving upon its axis, it takes round the chain and buckets, and so produces the complete effect of filling and discharging the dredging-buckets into the receiving barge, or boat, moored alongside for this purpose, as represented in the Plate.

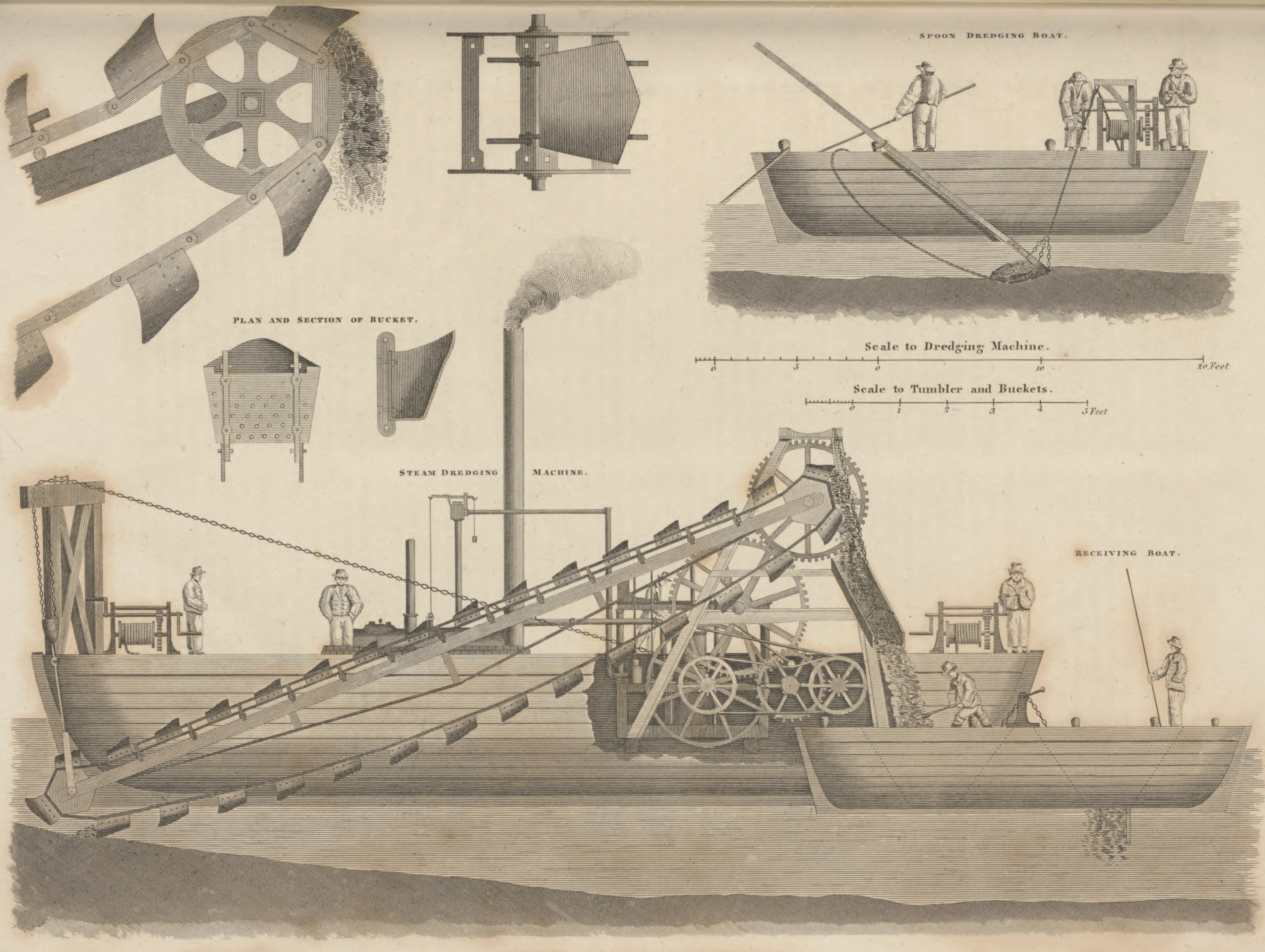
Receiving Boats.

If these excavated matters are not required as ballast for shipping, as on the Thames, or for embanking and filling up behind the piers, and other purposes connected with the works at the place, the receiving boat is generally made with two holds sloping towards the keel or bottom, for the purpose of lessening the width of the discharging apertures, which are shut with hatches, or rather with *hinged doors*, as will be observed by the dotted lines delineated on the elevation of the receiving boat in the plate. These hatches or doors open outwards, and therefore, as the boat receives its cargo, the increasing pressure of the water, acting in a contrary direction, prevents the doors from being forced open by the weight of the stuff, till it be transported to the place of its destination; when the chains, fixed to ring-bolts on these doors, are loosened by turning a windlass or crane work upon deck, when the whole contents instantly drop into the water. On the Continent much use is made of this description of boat in dredging operations.

Though we have not been able to trace the invention of the bucket dredging-machine to any particular person, yet we believe it is strictly of British origin, and, so far as our information goes, it was first used at the port of Hull in the Humber. We know that the application of the steam-engine was proposed as part of the establishment at the royal dock-yards, for *towing* or dragging ships, by an ingenious person of the name of Jonathan Hull, so far back as the year 1736; who, at that early period, obtained a patent for his invention. About the year 1787, or nearly forty years afterwards, the late Mr Miller of Dalswinton, distinguished for his curious nautical experiments, introduced the steam-engine into one of his boats, with three keels, for plying upon the open sea. The late Earl of Stanhope, well known for his many ingenious contrivances, also laboured in the same important branch of mechanics. These circumstances alone are sufficient to prove the steam-boat to be of British origin; but it is probable that steam was not applied to the dredging-apparatus prior to the year 1800, nor brought into general use in Great Britain sooner than 1812, by Mr Bell of Helensburgh, on the Clyde.

Since the first rude and simple attempts at this machine, very considerable improvements have been made both in its construction and application. The figure of the dredging-machine, delineated in the plate, is simple in its form, and contains the latest improvements, both in the position and arrangement of the machinery and of the dredging-frame. The form of the vessels on which this apparatus is mounted is very different; but the great object to be attended to in framing vessels for this purpose, is to obtain such a sufficient degree of strength as not only to withstand the tremulous motion of the engine and machinery, which is apt to shake the timbers of the vessel, but to resist the strains to which a vessel so employed must be continually liable.

These vessels are very different in their tonnage and dimensions, including a range from about 50 to upwards of 220 tons. The smallest machine on this principle is, perhaps, that already noticed at Greenock, which, exclusively of receiving boats, is worked by about eight men. Perhaps the largest vessel in which a steam-engine is employed, is at the works of the Caledonian Canal; where about the same number of men are occupied in attending the vessel and steam-engine. At Greenock, from 70 to 90 tons of silt and mud are lifted *per* day; but on the Caledonian Canal, about 400 tons have been



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removed in the same period, in deepening Loch Doughfour, where the bottom is of rough gravel. Here, independently of the value of the apparatus, the expence has been found to be about ninepence *per* cubic yard, including the expence of removal in barges; a rate which, compared with the usual tedious operation of digging and carting in tide harbours that are quite accessible, will be found to be extremely moderate. When we consider the situations in which the process of dredging is usually performed, this mode of excavating under water cannot fail to strike every one as an immense improvement in the hands of the engineer.

On the Thames, the bucket dredging-machine is also in use, though the work there is chiefly done with the spoon apparatus. One of the dredging machines on the river at London has a bucket frame working at each side of a vessel of about 100 tons burden, furnished with an engine of the power of sixteen horses, which excavates about 300 tons *per* day.

Expence of the Process.

It is found that gravel and small stones are more easily excavated than silt or mud. In a general way, we may estimate that a bucket dredging machine, in good order, fitted up with one of Watt and Bolton's steam-engines, of the power of about twelve or fifteen horses, on a vessel of 100 or 120 tons, with two or more receiving boats, according to the distance of removal, and working in a situation sheltered from the *lift* or swell of the sea, and in a *tide way*, not exceeding one or two miles *per* hour in velocity, nor more than two fathoms in depth, will lift from 120 to 160 tons, or at the rate of about 30 or 40 tons *per* hour; and according to the situation of the work the expence will be from fourpence to one shilling *per* cubic yard. The cost of a dredging apparatus, complete, with an engine of the power of twelve or fifteen horses, will be about L. 3500. The expenditure of coals for such an engine may be taken at the rate of about $2\frac{1}{2}$ cwt. *per* hour; and the daily expence of the whole, including the value of the apparatus, and men for every purpose, will amount to from three to five pounds, according to the circumstances of the place where it is employed.

The strength of the vessel and fitness of the machinery, and also the security of the whole against accident by fire, are circumstances connected with the application of the dredging-machine, which will always meet with the consideration of the engineer; whose regulation of all the parts of this apparatus will be much guided by attention to the actual operation, as more or less suitable to the peculiar situation of the works in which it is to be employed. What we have been able to bring under the reader's notice in this article, we trust will be found sufficient to give him an idea of the construction of the apparatus, and the principles upon which it acts. To those who may not take much interest in the details of complicated machinery, we presume it will have been interesting to know how operations of this kind are performed, the quantity of work that may be done, and the rate of its expence. (H. H.)

DRYANDER (JONAS), a Swedish naturalist of eminent talents, and a distinguished pupil of the great Linnæus, was born in 1748. His father, a clergyman near Gottenburgh, died during the minority, if not the infancy, of his son; in consequence of which, the care of the education of the latter devolved on a maternal uncle. This was Dr Lars Montin, a member of the Stockholm Academy, known to the world by several botanical writings, and, amongst others, by an inaugural dissertation on the genus *Splachnum*, published under the presidency of Linnæus, March 28, 1750; and reprinted in the *Amœnitates Academicæ*, Vol. II. 263. The early education of young Dryander, as far as we can learn, was chiefly in the University of Gottenburgh; but he afterwards removed to Lund, where he took his degree of Master of Arts, or Doctor in Philosophy, under the presidency of Lidbeck, in 1776; on which occasion he published a dissertation, *Fungos Regno Vegetabili Vindicans*. He combated the ideas of certain philosophers, who, led by analogy rather than observation or judgment, were disposed to believe that *Fungi* might, like corals and corallines, be the production of animals. But though Mr Dryander thus asserted the vegetable nature of these bodies, he subsequently imbibed, from his friend and preceptor Linnæus, an insuperable dislike to their use as food, nor could the most delicate mushrooms, of the most luxurious table, ever tempt him to overcome this prejudice. We know not at what period he went to study at Upsal, nor how long he remained there. He became for some time domestic tutor to a young Swedish nobleman, after which he visited England, under the patronage of his countryman, the well-known Dr Solander, who introduced him to the acquaintance of Sir Joseph Banks; and on the sudden death of Solander in 1782, he succeeded to the place of that eminent man, in the confidence and friendship of his distinguished patron. He was, in like manner, domesticated under the roof of Sir Joseph, as his librarian, and continued in that situation as long as he lived. Mr Dryander also held the offices of librarian to the Royal and the Linnæan Societies. He was one of the first founders of the latter in 1788; and took a principal interest in all its concerns, especially in drawing up its laws and regulations, when this society was incorporated by royal charter in 1802. He, moreover, fulfilled the duties of a very active vice-president, till the time of his decease, which happened towards the end of October 1810, in the 63d year of his age. His remains were deposited in the vault of St Ann's Church, Soho, the funeral being attended by a number of his friends, principally members of the Linnæan Society.

The acknowledged publications of Mr Dryander on the subject of botany consist of the following dissertations: 1. *An Account of the Genus Albuca*, in the Stockholm *Transactions* for 1784, in Swedish. 2. *Observations on the Genus Begonia*, in the *Transactions of the Linnæan Society*, Vol. I. In this essay twenty-one species are determined, with an indication of nine doubtful ones, though the genus was previously supposed to consist of a solitary species only. 3. *On Genera and Species of Plants* which occur twice or three times in Professor Gmelin's edition of Lin-

næus's *Systema Naturæ; Trans. of Linn. Soc.* Vol. II. These corrections unfortunately extend no further than the class *Octandria*. Their author intended to have completed them, but other occupations intervened; and the book, which was the object of his correction, soon fell into absolute neglect, as far as regards botany; insomuch that its errors, however great and numerous, became harmless. 4. *Lindsea, a new Genus of Ferns; Trans. of Linn. Soc.* Vol. III. This genus is distinguished from *Pteris*, by the *involucrum* opening outward. 5. *Botanical Description of the Benjamin Tree of Sumatra*, in the *Phil. Trans.* Vol. LXXVII. The tree in question, about which great mistakes had arisen, is here shown to be a species of *Styrax*. This paper has been republished and translated.

The principal works, published under the superintendence and correction of the subject of this memorial, were, the *Hortus Kewensis* of Mr Aiton, printed in 1789, and about half the second edition of the same work, interrupted by his death; as well as Dr Roxburgh's *Plants of the Coast of Coromandel*, a splendid and highly valuable publication, for which the world is indebted to the munificence of the East India Company. To both these the critical learning and accuracy of Mr Dryander were most usefully applied, especially in the typographical department. It would be vain to seek for an error in the printing of any thing which had passed through his hands. We have only to regret, that the same critical correctness was not extended, as a principle, to every other department of the works in which he took a part. Had this been the case, the erroneous essential character of *Oldenlandia*, copied in *Hort. Kew.* from Linnæus and Willdenow, would not have been allowed to contradict the plate and description of Roxburgh, cited underneath. But, above all, various inaccuracies and faults in nomenclature are propagated and confirmed by an authority which Mr Dryander himself never intended to give. He has often assured the writer of this, that, had he published in his own name, he would not have adopted such inaccuracies; which is mentioned here, to prevent the errors of others being laid to his charge. The popular *Species Plantarum* of Willdenow being the avowed guide, the author of that work must be responsible for matters, which it did not come within the scope of the author or editor of the *Hortus Kewensis* to correct. Many subjects, however, are most skilfully elucidated in this publication, as well as in the sequel of its second edition by Mr Brown, and these cannot escape the discrimination of an intelligent reader. Practical botany was but a secondary or occasional pursuit of Mr Dryander, and he had a diffidence of his powers, and a consequent distaste, for the technical and descriptive parts of the science. The descriptions he had prepared for Mr Bauer's splendid figures of *Ericæ*, published by Mr Aiton, were readily, and even gladly, thrown into the fire, on occasion of a difference of opinion respecting the intended title of the work.

The study in which this most acute and correct man found ample scope for the exercise of his talents, was bibliography. His *Catalogus Bibliothecæ Historico-Naturalis Josephi Banks*, is a model for all future writers in this line; but a model rather calculated to check than to excite imitation. A work so ingenious in design, and so perfect in execution, can scarcely be produced in any science; so faultless a specimen of typography we have never elsewhere seen. The frank and unvarnished sincerity of Mr Dryander's character was secondary only to his universal and fastidious exactness upon every subject that came under his notice. He could not be the silent witness of the slightest injustice, misrepresentation, or misconception. His impatience of contradiction arose more from the quickness of his penetration into the confusion and inaccuracy of ordinary intellects and characters, than from any natural severity. All clearness, honesty and precision himself, he had little indulgence for those who fell short of his standard, and these were the greater part of mankind. On being asked what share Dr Smith had in the composition of the *Flora Græca*? He replied, with a vehemence that startled the inquirer, "Every word!" When teazed, as was too often his lot, by the questions of the heedless and superficial, he never neglected the duties of the office he had undertaken, if he could not always conceal his impatience under their performance. But when the humblest cultivator of real science applied for his assistance, all his stores were laid open; the most condescending liberality graced his conversation; and he was careful that what he communicated should not only be heard but understood. The versatility of his genius and conversation was no less admirable than their exactness. Whether the subject were a question in science, or a point of history; the politics of Europe, or the tittle-tattle of an obscure German court; the literary talents and performances of any distinguished man, or his private transactions; the intrigues for a place at court, a professorship, or a domestic establishment, he was sure to throw some light upon it. Few men are more missed in the circle in which he moved, nor can his place in general society be readily supplied.

(J. J.)

DRY-ROT,

Dry-Rot.

A most destructive, and apparently infectious, disease in timber, which, by decomposing the fibres, deprives it of all strength, and, in no great length of time, reduces it to a mass of dry dust,—a circumstance from which it seems to have derived its name, which, perhaps, would better be expressed by that of *sap-rot*.

Though this disease must, from its nature, have been co-existent with timber trees, it would not seem to have excited much attention, and perhaps was not known, certainly not by its present name, beyond the middle of the last century; at some period, we rather think, of Sir John Pringle's presidency of the Royal Society of London. But for a long time after this, little notice appears to have been taken of it; its ravages being, in all probability, inconsiderable in comparison with what they have been of late years. Even now the disease is, in fact, chiefly confined to modern built houses, and modern built ships, and more particularly to the ships of his Majesty's navy. The proximate cause of it has, therefore, rightly enough, as it would seem, been ascribed to the unseasonable state of the timber, when placed in certain situations, and under particular circumstances.

Alarming Progress of.

It could not fail, in the course of the late long protracted war, to become a matter of general observation, that a more rapid decay than usual was become almost universal throughout the fleet; and especially among the newest and most recently repaired ships. Many anxious inquiries were instituted, and experiments made, with the view of ascertaining the real cause of a decay, the further prevention of which was so highly important to the national welfare and security. The alarm was greatly increased when, in 1810, the Queen Charlotte, a first-rate ship of war, shortly after launched at Deptford, was discovered, after a close examination, to have all her upper-works infected with the *dry-rot;* or, in other words, the ends of most of the beams, carlings, and ledges, the joinings of the planks, &c. were observed to be covered with a mouldy, fibrous, and reticulated crust, and the parts of the timber so covered to be perfectly rotten. All the newspapers and journals of the day were filled with this alarming fact, and, in consequence thereof, a multitude of *dry-rot* doctors proffered their assistance; one having a nostrum for eradicating the disease where it had made its appearance, and another for preventing its farther approach. Some of these specifics were expensive and inconvenient, many of them impracticable of application, and most of them futile and objectionable in one way or another. These doctors, in fact, like the physicians for the human body, when the seat of the disease is unknown, were labouring altogether in the dark, having no other guide to direct them than their own whims and fancies, each being ignorant of the effect of the respective experiments which they wished to try on this diseased machine.

Treatises on the Dry-Rot.

Since the period in question a number of treatises have been written on the subject for the prevention and cure of the dry-rot in ships and houses; some wild and visionary enough, and others exhibiting the proofs of plain practical good sense, deduced from long observation, or the result of judicious experiment. Of the latter description may safely be mentioned *A Treatise on the Dry-Rot in Timber*, written in 1815, by the late Mr Thomas Wade, who died previous to its publication, and while employed in making experiments in the dock-yards; and also another *On the Prevention of Timber from Premature Decay*, by Mr Chapman, 1817. *A Treatise on the Dry-Rot*, by Mr Bowden of the Navy Office, is, in many respects, deserving of notice, in as far as the facts and his observations on the management of timber are carried; but he unluckily sets out with a fanciful theory (which, however, is not his own), concerning the generation of *fungi*, and their connection with the dry-rot, to which, like most theorists, he endeavours to make all his facts subservient. In Mr M'William's *Essay on the Origin and Operation of the Dry-Rot*, published in 1818, we find stuffed into a large quarto, almost every theory and every fact gathered from preceding writers, from Aristotle down to Mr Ralph Dodd, civil engineer, who has also published his *Practical Observations on the Dry-Rot in Timber;* which work appears to be little more than an advertisement of *A Dry-rot Preventative*, a nostrum which, it would seem, is too valuable to be disclosed, without calling in the doctor that he may get his fee. We have also in print the opinions and the specifics of Mr Gregory, Mr Ogg, and many others of minor note, all of whom profess to explain the cause, to secure the prevention, and to effect the cure of the *Dry-rot*.

Process of the Common Rot.

These authors are at variance among themselves, whether the *common rot* in timber, and the *dry-rot*, be not one and the same disease. A little reflection, however, will, we conceive, lead us to consider them as essentially different, both in the symptoms, the progress, and the causes, though the *effect* of destroying the fibre of the wood is pretty nearly the same. If a post of wood, for instance, be driven into the ground, seasoned or unseasoned, it will speedily begin to decay just at the surface of the ground, or as it were between the earth and the air; if driven into the earth through water, as in a pond, the decay will commence at the surface of the water, or, as it is technically expressed, between wind and water, while all above water, and all that is constantly immerged in the water, as well as the part in the earth, will remain sound. Thus, also, a beam of wood let into a damp wall, will begin to rot just where it enters the wall, so will wooden bannisters when they are let through the top and foot rails. In these and similar cases, the rot begins externally, and its progress is inwards, and is more or less accelerated by the alternate action of wind, heat, and moisture, be-

Dry-Rot.

ing *greatest* when the alternatives of exposure to wet and drought are most frequent, and *least* when constantly immersed in water, or constantly preserved in a dry atmosphere. Such we conceive to be the usual process of the *common rot* in wood, and it is evidently occasioned by alternate exposure to the vicissitudes of the weather—to moisture and dryness—to heat and cold

Process of the Dry-Rot.

If the same post be well charred or covered over with a thick coating of paint, or varnish, or tar, no such effect will be produced *externally*, the coating being sufficient to protect it against the action of the weather; but if it should happen to be a green or unseasoned piece of wood so tarred or painted, in no great length of time the wood will be found to have begun to decay *internally*, while the outer surface appears uninjured, but at length it will also yield to the disease. If this piece of wood had been placed in a warm cellar or close room where there is little or no circulation of air, and more particularly if the room or cellar were damp, there would be perceived, in no great length of time, a fine mouldy coating spread over its surface, of a brownish yellow or dirty white, and shortly afterwards it would be found, on examination, to resemble in its form and structure some of the beautiful ramified *algæ* or sea-weeds; which, in process of time, would become more compact, the interstices being so completely filled up as to give to the whole mass the appearance and consistence of leather. "At first," says one writer, "its appearance is that of fine fibres running on the surface in endless ramifications, resembling the nervous fibres of leaves; presently the interstices are filled up with a spongy or leather-like substance, assuming the character of that order of cryptogamous plants, distinguished by the name of *fungus*."

By Mr Wade the general symptoms of *dry-rot* are thus described: "The wood at first swells; after some time it changes its colour; then emits gases which have a mouldy or musty smell. In the more advanced stages of it, the mass arises, and cracks in transverse directions. Lastly, it becomes pulverulent, and forms vegetable earth; and generally in some of these stages of decay, the different species of fungus are found to vegetate on the mass." (*Treatise on the Dry-Rot in Timber*. By Thomas Wade.)

These appearances do not invariably take place, the surface of the diseased timber sometimes remaining unchanged, while the process of rotting is going on within; but they are pretty constant. But however sound the surface may be, it will appear, on examining the piece of wood, placed in a situation similar to those above mentioned, that the whole of the interior fibres are decomposed, and become a mass of dust inclosed within a thin external shell. No charring of the surface, no paint, tar, or varnish, will prevent this process from taking place, when the seeds of the dry-rot exist, and are placed in a situation favourable for their growth, though they may prevent the external character of mouldiness from taking place on the surface.

Characteristic difference of the two Rots.

The symptomatic difference, then, between the common rot and the dry-rot, may perhaps be thus defined. *Common rot* is a disease in timber, occasioned by the alternations of the weather acting on its surface, and destroying its fibres externally inwards. *Dry-rot* is a disease in timber, occasioned by being shut up in warm, close, and moist situations, the effect of which is to destroy its fibres by a process acting internally outwards.

Causes of the Dry-Rot.

Without stopping to inquire in what manner, and by what agency, chemical or mechanical, or both, the common rot acts on the external fibres of the wood, the effect of alternate exposure to the weather is too well known to require any further proof, as to its being the immediate cause. The immediate cause of the dry-rot is equally obvious; but, the predisposing state of the timber to contract the disease is not quite so clear a problem. Accordingly, theories without end have been hatched, to explain the phenomenon. A writer in a public journal, who has slightly touched on the subject, thus explains it. "It is well known," he observes, "that if a piece of green wood be laid across a fire, the air within, expanded by the heat, will drive out at each extremity a viscous fluid, possessing the property of disposing itself on the surface in reticulated filaments. The same appearance of nervous foliation is not uncommon in the intermediate spaces of the concentric layers of the *alburnum* of wood; and the core or heart of trees, and particularly of the pitch pine, after its passage in the heated hold of a ship, is often enveloped with a membranous corticle, like that which lies immediately beneath the bark. All these appearances are certain indications of the *dry-rot;* and they point out, with sufficient clearness, that the *sap* or principle of vegetation, brought into activity, is the *cause* of the disease; the *effect*, though infinitely more rapid, is the same as that of the common rot. It is still a problem in what manner this sap circulates; but there is no doubt that the tubes and cells of the alburnum, or sap-wood, are filled with it in the spring of the year, and that they are empty in the winter;—that it is organized matter, developing itself by heat in all the various forms of new bark, leaves, and branches. The stem of a tree cut down will, on the return of summer, make an effort to push out leaves; a more feeble effort of this organized sap ends in the production of *fungus* only." —(*Quarterly Review*. No. 15.)

It is now, we apprehend, pretty well decided, that like other vegetables, the fungi or mushroom tribe are propagated by seed, so minute and numerous as to float about invisibly in the air, and to be carried into all manner of situations. The fine impalpable powder that issues from the common puff-ball, like a column of smoke, will give some idea of the almost inconceivable myriads of minute seeds which it incloses. Of these seeds, though myriads perish, yet others, by a concurrence of accidents, being thrown into proper situations, favourable for their growth, reproduce the species. It cannot be supposed that the fibres found in the dung of animals, and particularly of the horse, known by the name of mushroom spawn, and from which our gardeners construct their mushroom beds, are generated spontaneously in the belly of the animal, but that the seeds being devoured with his food, have found that degree of warmth, moisture, and soil, favour-

able to the developement of the future plant; and this plant which the fibres exhibit, by care and cultivation increases and grows to the perfect state of all plants, and throws out above the surface the parts of fructification which we call the mushroom. If it be asked why the dung of a cow, which feeds on the same food with a horse, does not produce the spawn of mushrooms, the only answer to be given is, that it is not a proper nidus for the germination of the seed.

In the same manner may the perfect plant be produced from the seed, carried up into the longitudinal tubes of a growing tree, by the rising of the sap; though it would seem that the process of vegetation in the parasite thus lodged, will not commence so long as the vital principle of the sap in the tree remains in activity. Indeed, it is pretty evident, from numerous observations, that the process of fermentation is necessary to the growth of all fungi; and this may explain why in the diseased and decayed parts of a tree only are fungi found to grow, while it is in a living state.

The sap, therefore, may be the *cause* of the *dry-rot*, in so far as it is favourable to the growth of *fungi*, as it would seem to be when in a state of fermentation, though it never can by any process be convertible into this order of cryptogamous plants. But the appearance of fungi, though a frequent, is by no means a constant symptom of *dry-rot;* and, therefore, Mr Bowden's definition of dry-rot, with his whole doctrine, must fall to the ground. "The *nature* of *dry-rot* is a *vegetable substance*," and this substance, he tells us, is fungus. Though not very happily expressed, his meaning is intelligible enough from what follows. "This secretion of nature (the juice of a tree) which was destined to appear in the form of leaves, branches, &c. being diverted from its original intention, assumes a new form from its own native energies. Vegetation commences in the various tubes of the wood, under the form of those fine fibrous shoots, which have been already described (as mushroom spawn). It continues to increase in every direction, until, by an extraordinary manifestation, it happily averts the otherwise unforeseen but certain destruction of the vessel. It may confidently be asserted, therefore, that this is the primary, chief, and predisposing cause of *dry-rot;* and this opinion may be further confirmed by an inquiry into the nature of the juices and fungi, and the manner in which the timber is affected." (*A Treatise on Dry-Rot*, by A. Bowden.)

Mr Bowden having totally mistaken the nature of fungus, by adopting the erroneous principle of the writer in the *Quarterly Review*, labours hard to prove, and with considerable ingenuity, "that dry-rot is caused by a vegetative substance, and that it is one of the species of *fungi;*" and this doctrine he illustrates in the case of *spent bark* from the tan-pits, of which he says, "when taken out and exposed to the heat of summer, the juices appear desirous of *obeying the laws of nature;* and being no longer capable of adding to the bulk of a tree, is satisfied with wearing the humble garb of a mushroom;"—nay, so enamoured is he with the similarity of oak bark, and fungus, and *tannin*, that "an examination of the fungous coat taken from the end of a timber, would afford a strong presumption, from its exact resemblance to *leather*, that it owes its existence to no other cause than that which communicates such peculiar qualities:"—into such absurdities will crude theories sometimes drive their authors.

Mr Wade has sounder notions on the nature of fungi: he knew they possessed the principle of reproduction, and that their seeds, under favourable circumstances, will vegetate; and that the proper *nidus* for the reception of certain species of fungus appears to be wood in a state of progressive decomposition, or the remains of wood entirely decomposed; that, however, the effect produced by these plants and decaying timber is reciprocal; the latter furnishing food for the former, while the decomposition of the wood is accelerated by the growth of the fungus, the gaseous and soluble products being taken up by the plants, as quickly as these principles are disengaged. The whole tribe of parasitic fungi may, in fact, be considered as the wolves and tigers of the vegetable world, destroying ultimately every plant they fix upon, and most rapidly where the principle of vegetation has ceased to act, and the putrefactive fermentation of the juices has in consequence commenced.

The real efficient cause then of the dry-rot, is that of the juices of the timber being brought into a state of putrefaction, occasioned generally by exposure to a moderate degree of heat and moisture in a stagnant atmosphere. "To favour this process," says Mr Wade, "as much as possible, the air and water should not be renewed, as they undergo a decomposition, which takes place very slowly." From the structure of timber being composed longitudinally of an assemblage of pipes or tubes, it is only necessary that one end of a log of wood should be placed in a damp or wet situation, to occasion the moisture to be conveyed to the opposite end by capillary attraction; and hence arises the infectious nature of the disease, which will always spread wherever the moisture finds its way; and even where there is no moisture, it will be created by the filaments of the fungi working their way through the tubes of the dry wood, and carrying it with them. Hence, also, the rapid decay in ships of war, from the great internal heat occasioned by the number of men, the moisture, and the close air. Hence, also, in houses, the *dry-rot* always first appears in the lower apartments, where the floors, partitions, skirting-boards, &c. are supplied with moisture from the wet walls on the ground. In the London houses, there is generally a room on the basement story, called the housekeeper's room, which is boarded, and carefully covered over with an oiled floor-cloth. In such a room the dry-rot is sure to make its appearance. The wood absorbs the aqueous vapour, which the oil-cloth will not allow to escape; and being assisted by the heat of the air in such apartments, the decay goes on most rapidly; and, as Mr Wade observes, "if the seed of fungus be present, the plant is developed in all the superfluity of vigour exhibited in a hot-house, where the same means are resorted to, namely, an atmosphere scientifically and artificially heated, and highly charged with aqueous vapour." Timber may, in fact, have the seeds of dry-

rot within it, and yet by proper treatment be kept sound for a great length of time. Thus ships, laden with particular cargoes, afford remarkable instances of the effects of such cargoes on their duration. The warm moisture, created by a cargo of hemp, is communicated to the timber, and promotes a rapid putrefaction. Mr Chapman says, that the ship Brothers, built at Whitby of green timber, proceeded to Petersburgh for a cargo of hemp. The next year it was found on examination that her timbers were rotten, and all the planking, excepting a thin external skin. A lading of cotton is always injurious to the ship, and even teak is affected by a cargo of pepper. The timber which is brought from America in the heated hold of a ship, is invariably covered over, on being landed, with a complete coating of fungus: it was the too general use of this timber in his Majesty's ships that at one time increased the disease to such an alarming degree. Those ships, on the contrary, which are employed constantly in the coal and lime trade, are very durable, and have been known to last for a century. These effects are obviously to be ascribed to the exclusion of air in the one case from, and the free admission of it in the other to, the interior surface of the ship, assisted, in the latter instance, by the absorption of moisture, by the coals and lime, from the timbers and planking.

Prevention of Dry-Rot,

If we are arrived at the right conclusion as to the *cause* of *dry-rot* in timber, we can be at no loss with regard to the mode of treatment for the *prevention* of the disease. The experiments for this purpose have been very numerous, but may be classed under three general heads:—desiccation or seasoning; immersion in earth, sand, or water; and impregnation with some foreign matter, which will resist putrefaction.

by Desiccation or Seasoning.

The most simple and common mode of preventing the decomposition of vegetable matter, is by depriving it of moisture. Various schemes have been put in practice for drying the juices in large logs of timber. Time alone will do it when the wood is placed in favourable situations, that is to say, in a dry atmosphere, and constantly exposed to a free circulation of air; but time will also produce the rot in timber when piled up in stacks in the open air, imbibing moisture from the earth, and exposed to the vicissitudes of the seasons, and the alternatives of weather; scorched at one time by the heat of the sun, at another, drenched with rain, and rent and split in every possible way by the freezing of the water, which has insinuated itself into the pores and crevices of the wood. It was formerly, and, indeed, till very lately, the practice to let ships of war remain on the stocks *in frame* for two, three, or four years to *season*, as it was called, but there never was so mistaken a notion. "When a ship," says Mr Wade, "is built, exposed to the weather, the lower part forms a grand reservoir for all the rain that falls, and as the timbers in that part are placed as close together as possible, the wet escapes very slowly. Those timbers are always soaked with moisture, and to some distance from the keel, exhibit a green appearance; their green matter, when viewed through a microscope, is found to be a beautiful and completely formed moss, which vegetates at the expence of the timber. If to season timber be only to dry it, the sooner it is dried the better; and when completely dry, it cannot too soon be employed in ship-building, when it should be kept dry. It cannot answer any end to have seven years wear out of a ship on the stocks." At length our ship-wrights are convinced of this truth, and every ship of war now building in the dock-yards has excellent roofs placed over them, with the sides open to admit a free current of air, but to exclude all moisture, as well as the rays of the sun (See Dock-Yards); a practice which we have tardily adopted from the Swedes and the Venetians. A new system seems also to have been adopted on the piling the timber stacks. Instead of their being placed on old, useless, and often rotten logs of timber resting on the ground, they are now insulated from the earth on stone or iron pillars; and in the place of their surfaces coming in contact with each other, pieces of wood are placed between them so as to admit of a circulation of air. Nothing further appears to be wanting, but to protect the tops and the ends of the stocks or piles from the effects of the weather.

Of the various modes of artificial and rapid desiccation, that of charring is perhaps the best; but it is liable to two objections; the first is, that if the surface be completely charred, it diminishes very much the strength of the timber; and, secondly, it the more readily attracts moisture. The juices of timber may be drawn off or hardened by kiln-drying; but this also disturbs the arrangement of the fibres, and deprives the wood of a great part of its strength.

Mr Lukin's Experiments for seasoning Timber.

The experiments made by Mr Lukin for the rapid seasoning of green oak timber, promised at one time much success, but ended in disappointment. He conceived, that, if the acid and the watery particles were driven out of a piece of oak timber by some process which should prevent the surface from splitting, the fibres would be brought closer into contact, and while the log lost in weight, it would gain in strength. With this view, he buried a piece of wood in pulverized charcoal in a heated oven. The log wore a promising appearance; the surface was close and compact; it had lost in its weight and dimensions; but when divided with the saw, the fibres were discovered to have started from each other, exhibiting a piece of fine net-work, resembling the inner bark of a tree.

His next contrivance was to supply the place of the fluids driven out by heat, with some other substance of an oily or resinous nature, which, while it destroyed the principle of vegetation, should preserve the timber in a compact state. For this purpose, he erected a large kiln in Woolwich Dock-yard, capable of containing from two to three hundred loads of timber. At each end, on the outside, was a retort in which the saw-dust of the pitch-pine was submitted to distillation. From the heads of these retorts were iron pipes, perforated with holes like a cylinder, continued along the upper part of the kiln the whole length in the inside. By this arrangement it was expected that while the heat of the kiln drove off the aqueous matter of the timber, the product of the saw-dust, which resembled weak oil, or rather spirit of turpentine, would drop through the holes in the tubes upon the logs and supply its place.

But before the process of transfusion was judged to be complete, an explosion took place, which proved fatal to six of the workmen, and wounded fourteen, two of whom shortly afterwards died. The explosion was like the shock of an earthquake; it demolished the wall of the dock-yard, part of which was thrown to the distance of 250 feet; an iron door, weighing 280 pounds, was driven to the distance of 230 feet, and other parts of the building were borne in the air upwards of 300 feet. The experiment was not repeated.

The bad effects of applying artificial heat to the seasoning of green timber were strongly exemplified by a practice introduced very generally into our ships of war, which had exhibited indications of the dry-rot, particularly in the Queen Charlotte. Enormous fires were made in stoves placed in various parts of the ship, and the heat led in tubes to the cavities between the timbers, &c. The consequence of which was, as might be expected, an increase of the mischief they were intended to prevent. Every part of the ship was converted into a hot-house, and every part where the seeds of fungi had been deposited, began to throw out a luxuriant crop of mushrooms; and where these did not appear, the juices of the wood were thrown into a state of fermentation, and, in the course of a twelvemonth, a great part of her upperworks became a mass of rottenness. After staving the powder magazines of some of the ships, there appeared under their floors, which are contiguous to much moisture, numbers of large excrescences of a leathery consistence, of the size and shape of a quart glass decanter; and in all such parts where two surfaces of the wood were imperfectly brought in contact, were whole masses of fungi.

Winter-Felled Timber.

Another mode, of very ancient standing, was practised for getting rid of the juices of timber. This was supposed to be effected by felling the tree in the winter season, when the sap had descended and the vessels were empty. But by this practice, the bark of the oak, so valuable in the process of tanning, was lost, as it will strip only from the wood in the spring of the year, when the sap is said to be rising. The supposed superior quality of the wood when winter-felled, and the general practice of felling oak timber at that season, may be inferred from a statute of James I. whereby it is enacted, that no person or persons shall fell, or cause to be felled, any oaken trees meet to be barked, when bark is worth 2s. a cart-load (timber for the needful building and reparation of houses, ships, or mills, only excepted), but between the first day of April and last day of June, not even for the King's use, out of barking time, except for building or repairing his Majesty's houses or ships.

The old *Sovereign of the Seas* is the standing example generally quoted to prove the beneficial effects of winter-felled timber. We are informed by one writer that, when taken in pieces, after forty-seven years' service, the old timber was still so hard, that it was no easy matter to drive a nail into it, and all future writers have taken it for granted, that this was owing to its being winter-felled. Mr Pett, however, who built her, takes no notice of any such circumstance. He merely says he was commanded by the King, on the 14th May 1635, to hasten into the north to procure the frame-timbers, plank, and trenails, for the great new ship at Woolwich. But he left his son behind to ship the moulds, provisions, and workmen in a hired ship, to transport them to Newcastle: that the frame, as it was got ready, was sent in Colliers from Newcastle and Sunderland; and that, on the 21st December, *in the same year*, the keel was laid in the dock; and in less than two years after this she was launched. Now, as it was the middle of May before Mr Pett received his Majesty's commands to procure timber for this ship, and as she was on the stocks the same year, it is not very probable that the timber procured and sent in Colliers from Newcastle to Woolwich was felled in the winter; much less could it have been "stripped of its bark in the spring, and felled the *second* succeeding autumn," as Mr Wade has it.

Neither is there the least proof of the old *Royal William*, recently broken up, when a century old, being built of winter-felled timber. The fact is, that she was rebuilt half a dozen times, and the only old and original timber remaining in her was in the lowest part of her hull, always immersed in the salt water externally, and washed with the bilge-water internally; and the wood from this part of her, when broken up, was perfectly sound, but quite black, having the appearance of being charred.

As far as experiments have been made of late years, there is no reason to conclude that timber felled in the winter, is at all more durable than that which is felled at the usual time. In the year 1793, the Hawke, sloop-of-war, was ordered to be built, one side being of timber that had been barked in the spring and felled in the winter, and the other side with timber felled at the usual time. In 1803, she was reported to be in so bad a state of rottenness, that she was ordered to be taken in pieces, when no difference whatever could be discovered in the state of the timbers of the two sides. It is said, however, in Derrak's *Memoirs of the Navy*, "that the timber had been stripped in the spring of 1787, and not felled until the autumn 1790," and this is given as an explanation of the failure. Why the barking in the spring should add to the durability of timber, is not easily conceived, if the object be to fell the timber when all the sap-vessels are empty, as if the sap *descends* at all (which is doubtful), it might be expected to descend more freely when the bark is on than off the tree. The experiments which, we understand, are now making by the Commissioners of his Majesty's woods and forests, will, it is to be hoped, throw more light on a subject so vitally important to the British navy. In France, so long ago as 1669, a royal ordinance limited the felling of timber from the 1st October to the 15th April; and the conservators of the forests directed that the trees should be felled when the "wind was at north," and "in the wane of the moon;" and we find an instruction of Bonaparte, that "as ships built of timber felled at the moment of vegetation must be liable to rapid decay, and require immediate repairs from the effect of the *fermentation of the sap*, in those pieces which had not been felled at the proper

season;" the agents of the forests should abridge the time for felling naval timber, which should take place "in the decrease of the moon, from the 1st November to the 15th March."

Immersion in Earth, Sand, or Water.

The facts are so numerous and so strong in favour of the durability of timber, when steeped in water or buried in earth or sand, that no doubt whatever can be entertained of the efficacy of such a practice. At Brest all the timber used in ship-building is deposited in the narrow creek of the harbour which runs through the middle of the dock-yard, and it is said that the Brest built ships never had the dry-rot. The same practice prevailed at Cadiz and Carthagena. Indeed, there is reason to think that steeping in fresh-water is a preventive of dry-rot, probably by dissolving the juices of the timber. It was an ancient practice, and we believe is still followed in some parts of England, to place the timber intended for thrashing-floors in the midst of a stream of water to *harden* it, and all the oak planks intended for the wainscotting of the old mansions were previously steeped in running water.

"I know it," says Mr Chapman, "to be the opinion of some well informed men, whose sentiments are highly deserving of notice, that the sap of trees does not descend, but, like the arterial blood, is prevented by valves from returning; as a proof of which, it is asserted, that fresh cut timber, if laid in a running stream, with the but end towards the current, will have the water percollating through it, and carrying off the mucilaginous matter, but not otherwise." "There can be no doubt," he adds, "that the effect will be produced sooner in this direction than the other, and it should therefore be attended to." The reason is obvious; the extractive matter which is the chief, though not the only, cause of putrefaction, is dissolved and driven off. The usual mode of preserving timber for masts, is to keep it immersed in water in what are called mast-locks. The mast of the Kangaroo, sloop of war, was dug out of the mud at the bottom of the mast pond, at Deptford dock-yard, where it had been fifty years, and was one of the most serviceable masts in the navy. Burying timber in sand is an usual process for preserving it in warm climates. Yet, with all these facts and long experience, it was but the other day, that the steeping of timber in salt water was practised in the King's dock-yards, and this originated in an accident. The *Resistance* frigate went down in Malta harbour. But as she had been reported in such a state of dry-rot, or rather the surface of her timbers so covered with fungus as to render it expedient to send her home, she was suffered to continue under water for many months. On her arrival in England it was observed that all appearance of fungus had vanished, and she remains a sound ship to this day. Yet even this fact does not seem to have attracted much attention. But when the dock-yard was removed from the northern to the southern side of Milford-haven, a few loads of timber that was covered with fungus were suffered to remain in the water for several months; and it was observed, that, after being taken out and stacked in the new yard, the timber did not exhibit those appearances of dry-rot which the same timber did most abundantly which had not been immersed in the salt-water. This fact being reported to the Navy Board, it was proposed to sink one of two sister ships, the *Mersey* and the *Eden*, both alike infected with the dry-rot, in Plymouth Sound. The Eden was the ship selected for this purpose. She remained under water for about eighteen months, and, on being raised, every trace of fungus had totally disappeared, while the Mersey was almost wholly covered with it. After remaining a year at home perfectly sound, she was sent out to the East Indies, where she now is.

It is said, and there seems to be no reason for doubting the fact, that the planks of ships near the bows, which are obliged to be boiled in water or steam, in order to bend them, are never infected with the dry-rot; if the water in which they are boiled be strongly impregnated with salt, the effects would probably be more durable and decisive.

In a lecture read by Mr Ogg, a salt refiner, to the Plymouth Institution, on the Prevention and Cure of Dry-rot in Ships of War, common salt is strongly recommended for its cheapness, its wholesomeness, and its easy application; but he proposes a saturated solution of salt, in which he would steep not only single logs or planks, but the whole frame of a ship, or even the ship itself. "Let every ship in the navy," says the salt refiner, "be immersed a sufficient time in this fluid, and let every new ship be prepared in the same way, and dry-rot would be heard of no more. But how is this to be accomplished? I answer, provide a dock or docks sufficiently capacious to receive five, ten, or twenty ships, and the work is done." As common sea-water will answer the purpose equally well, the apparatus of extensive docks and water saturated with salt are wholly unnecessary. But Mr Ogg, like Mr Bowden, appears to mistake the real cause of dry-rot. "I affirm," says he, "that dry-rot is occasioned by the vegetative principle; brine will destroy this principle; then sink the ship in brine." The experiments in the case of the *Resistance* and the *Eden* show that brine is not necessary.

The Dutch having observed that their busses in which the herrings were caught and stowed away in pickle, lasted longer than any other craft, adopted the practice of filling up the vacancies between the timbers and planks of ships with salt, and of boring holes in the large timbers, and cramming them full of salt. The Americans also found, that the ships employed in carrying out salt for their fisheries and domestic purposes were the most durable; and both they and the Dutch are glad to get a cargo of salt into a new ship, as the surest means of preserving her. The carpenter of the *Franklin*, an American 74 gun ship, when at Spithead, told some of her visitors, that at the junction of the beams, and at the butt ends of the timbers, pieces were cut out, and the hollow part filled with salt, and covered over with felt, for the purpose of preserving those parts where two surfaces are imperfectly brought together, from the dry-rot, where it is always most prevalent.

There are, however, very serious objections to the immersion of ships in a strong solution of salt, and the practice of inserting salt in the vacant space between the timbers, which may not, perhaps, apply

with equal force to their immersion in sea-water. It is observed by a writer in the *Quarterly Review* for October 1814, that "the attraction for moisture which salts and acids possess, would keep the whole interior of the ship dripping wet; which would not only destroy the ship with the wet-rot, but the ship's company also, whose health, experience has proved, is best preserved by keeping the ship as dry as possible; and thus, the remedy would be worse than the disease." These bad effects have unquestionably been experienced; the muriate of magnesia, which exists in sea-water, being one of the most deliquescent salts; but whether the abstraction of moisture from the atmosphere be of long duration, is a fact which remains to be proved. In corroboration of the injurious effects above described, Mr Strange, in his *Evidences*, observes, "that the practice at Venice, of the fresh cut timber being thrown into salt water prevents its ever becoming dry in the ships, and that the salt water rusted and corroded the iron bolts." Mr Chapman also observes, that "the *Florida*, a 20 gun ship, taken from the Americans, and subsequently commissioned in the British service, had been salt-seasoned; and the result was, that in damp weather every thing became moist, the iron work was rusted, and the health of the crew was impaired: in fine," he adds, "vessels so circumstanced are perfect hygrometers; being as sensible to changes of the moisture in the atmosphere as lumps of rock salt, or slips of fuci, or the plaster of inside walls, where sea-sand has been used."

Mr Chapman, however, is of opinion, that vessels impregnated with bay-salt, or the large grained salt of Limington or of Liverpool (being pure muriate of soda, without admixture with the bitter deliquescent salts), will possess decided advantages, as would also vessels laden with saltpetre, if it has been dispersed among their timbers; and Mr Ogg sees no difficulty in refining salt so as to deprive it of its deliquescent quality. But if a very weak solution of salt, or even fresh water, shall be found to answer the purpose, the objection against immersing timber in sea-water seems to be got rid of. That it will immediately destroy all vegetable life in the delicate fibres of the fungus, and also prevent its future growth, is quite clear; and if it shall be found to prevent also the putrefactive process, it may be considered as the most advisable way to prepare timber for all purposes of house carpentry and ship-building.

Impregnation of Timber with Foreign Substances.

A great variety of substances besides common salt, indeed, almost any salt or acid, will destroy and prevent the growth of fungus. Sir Humphrey Davy recommends a weak solution of the corrosive sublimate as the most efficient. A solution of sulphat of iron or copperas is much used in Sweden for hardening and preserving wood for wheel carriages, &c. It is first boiled in this solution for three or four hours, and then kept in a warm place to dry, by which process it is said to become so hard and compact, that moisture cannot penetrate it. "The wooden vessels," says Mr Chapman, "in which the sulpho-ferruginous solution is finally placed for the copperas to crystallize, become exceedingly hard, and not subject to decay." A solution of alum has been recommended, but Mr Chapman seems to think, that its earthy basis would become a nidus of putrefaction. The wood, however, which is used about alum works, becomes hard and durable, and resists fire in an extraordinary manner. All timber, in fact, when completely saturated with saline matter, is more or less indestructible, and absolutely incombustible. A solution of arsenic has not been found to prevent the dry-rot. With regard to the impregnation of oils, there are various opinions, some thinking them beneficial, and others injurious to the durability of timber. It is known, however, that ships in the Greenland trade have their timbers and planks preserved, as high up as they are impregnated, with whale oil from the blubber; and Mr Chapman says, that one of the masters of a Greenland ship having payed her upperworks with twelve or more successive coats with whale oil in hot weather, they became covered with a thin varnish, much harder and more compact than if filled with successive coats of turpentine. Resinous substances, however, are probably better than oil.

After a variety of experiments, and sensible observations, Mr Chapman sums up the three great operations by which timber may be brought to resist the tendency to dry-rot.

1. To deprive the timber of its mucilage, which is very liable to fermentation.

2. To impregnate timber with any strongly antiseptic and non-deliquescent matter.

3. To dry timber progressively by the sun and wind, or by the latter alone; and then to close its pores completely with any substance impervious to air and moisture, and at the same time highly repellant to putrescency.

Mr Wade recommends the impregnation of timber with sulphats of copper, zinc, or iron, rejecting deliquescent salts, as they corrode metals, and would destroy the bolts and metal fastenings of a ship. He observes, that timber impregnated with saline matter is no longer capable of fermentation, and that, of course, the gases necessary for the nutriment of fungi are not evolved. Selinite is recommended as being insoluble or nearly so, and not liable to any alteration in the ordinary temperature of the atmosphere; but all salts, he observes, composed of barytes, should be rejected, because, though they are plentiful, cheap, and have some qualities eminently fitting them to be employed for this purpose, yet they are, without any exception, very poisonous.

From all experiments that have been made, it appears, that the most effectual method of preventing the dry-rot, and of giving durability to timber, is that of depriving the sap of its mucilage, more especially in the alburnum, where it most abounds; for though seasoning in the dry way will coagulate and harden the extractive matter of timber, yet when exposed to heat, moisture, and a stagnant air, the process of putrefaction will commence, and all the symptoms of dry-rot will speedily make their appearance. It will be preferable, therefore, that such timber as is likely to be exposed to the vicissitudes of weather, should be seasoned by immersion or impregnation, rather than by the dry way.

Cure of the Dry-Rot.

In this disease, as in those incident to animal life, prevention is much easier than cure. In fact, there is no other cure for the part affected than excision, and the sooner it is done the better; as the disease spreads most rapidly when fungi are propagated, throwing their minute fibres into the tubes of the contiguous sound wood, and producing that moisture which is a condition absolutely necessary to the putrefactive process. If, however, the fibre of the wood is still sound, and the roots of the fungi extend not beyond the alburnum near to the surface, immersion in sea water, as in cases of the *Resistance* and the *Eden*, or impregnation with some of the solutions above-mentioned, may stop the progress of the disease; but the only safe cure, we apprehend, is that of cutting out the infected part. The sinking of the *Royal George* at her moorings has not been the means of preserving her timbers. On being visited last year in the diving-bell, her oaken sides were broken down into a confused mass of timber and black mud; having, no doubt, been too far gone in decay when the fatal accident happened; but her fir deck appeared as sound as the day when she sunk.

Miscellaneous Observations.

It is a great mistake to suppose that the ancients were unacquainted with the dry-rot, or premature decay of timber. Pliny has a number of valuable observations on the preservation of timber, and on its decay occasioned by the juices; and, among other things, recommends that a tree should be cut to the heart all round, in order to let the juices escape, and that it should not be felled until the whole had run out. He knew that the sappy part of oak was more subject to rot, and advises that it should be cut away in squaring. He knew, too, that resinous and oleaginous matter in wood preserved it; observing, that the more odoriferous a piece of timber is, the more durable. He knew that much depended on the close texture of timber, and that box, ebony, cypress, and cedar, might almost be considered as indestructible. We also know that cedar, teak, and mahogany, are very durable woods.

The felling of timber while young and full of vigour, making use of the sap-wood or alburnum, and applying it to ships and buildings in an unseasoned state, have no doubt contributed to make the disease of dry-rot infinitely more common and extensive than it was in former times, when our ships were "Hearts of oak," and when in our large mansions, the wind was suffered to blow freely through them, and a current of air to circulate through the wide space left between the pannelled wainscoat and the wall. In those old mansions which yet remain, and in the ancient cathedrals and churches, we find nothing like the dry-rot, though perhaps

> ———" perforated sore
> And drill'd in holes, the solid oak is found
> By worms voracious eaten through and through."

Numerous examples of the extraordinary duration of timber may be produced, both from complete desiccation and exposure to the air, and from the complete exclusion of air and immersion in earth or water. Without adducing the surturbrandt of Iceland, covered with several strata of solid rock, or the logs of wood dug out of peat-moss, the antiquity of which is mere conjecture, we may instance the mummy cases of Egypt as being in all probability the most ancient timber in existence, that has been worked by the hand of man. When Belzoni entered the splendid tomb of the Kings of Thebes, in which was the transparent sarcophagus of gypsum, he found two human figures larger than life sculptured in wood, in as good preservation as if it had been worked in his own time; but the sockets of the eye, which had been copper, were entirely wasted away. We are told by Pliny, that the image of Diana at Ephesus, supposed to be of ebony, remained entire and unchanged, though the temple itself was ruined and rebuilt seven times. He adds that, in his own time, the image of Jupiter in the Capitol, made of cypress wood, was still fresh and beautiful, though set up in the year after the foundation of Rome 551, nearly 300 years before. He further says that there was a temple of Apollo at Utica, the timbers of which being of Numidian cedar, are said to have stood 1188 years. The roof of Westminster Hall, which is constructed of chesnut, has stood for more than 300 years, and is probably better now than when newly erected. Similar instances of the long duration of timber have occurred in situations where the atmospheric air has been excluded. In the Leverian Museum was a post said to be dug out of Fleet ditch, charred at the lower end, having the name of Julius Cæsar cut into it. The foundation on which the stone piers of London Bridge are laid, consist of huge piles of timber driven close to one another, on the top of which is a floor of planks ten inches thick, strongly bolted together; on these the stone piers rest, at about nine feet above the bed of the river, and, at low water, may be seen or felt at a very few inches below the surface. These piles have been driven upwards of 600 years, and from the solidity of the superincumbent weight, it may be concluded that they are perfectly sound. In the old city wall of London, timber is frequently dug out, as sound and perfect as when first deposited there. As the last instance of the extraordinary preservation of timber, we may mention, that, in digging away the foundation of the Old Savoy Palace, which was built about 650 years ago, the whole of the piles, consisting of oak, elm, beech, and chesnut, were found in a state of perfect soundness, without the least appearance of rottenness in any part of them; and the plank which covered the pile-heads was equally sound. Some of the beech, however, after being exposed a few weeks to the air, but under cover, had a coating of fungus spread over the surface, which affords a striking proof of the immense length of time that the seeds of this parasite will remain dormant, without parting with the principle of vegetable life, which is called into activity from the moment that they are deposited in a situation favourable to their growth. In this instance we have only to suppose, that the indurated juices of the wood became dissolved by its exposure to the moist atmosphere, and the phenomenon of fungous vegetation is capable of receiving a satisfactory explanation. (K.)

Dublin.

DUBLIN. A general account of this city will be found in the *Encyclopædia*, to which we now propose to add such further information as more recent publications afford.

General Description.

This city, the capital of Ireland, and in extent and population the second in the British empire, is situated near the mouth of the river Liffey, by which it is divided into two unequal parts. It stands nearly in the south-eastern extremity of an immense plain, which stretches considerably above 100 English miles from sea to sea, and which, though it is occasionally diversified by gentle eminences, is nowhere interrupted by hills. Originally the river Liffey, towards its mouth, overspread all the low grounds in the neighbourhood to such an extent, as to approach within eighty yards of the college on the south. To obviate these inconveniences, embankments on both sides, called the North and South Walls, have been raised along the river, as far as its mouth at Ringsend, by which a considerable tract of land has been recovered from the sea, while the channel of the river has at the same time been deepened. On both sides spacious quays have been erected, which communicate by means of bridges, at convenient distances, across the river. Below Carlisle Bridge, which is placed near to the mouth of the river, the only modern addition which has been made to Dublin is the new Customhouse, with a few houses either in its immediate vicinity, or scattered on the southern quay. The great accessions to the city are on the north-east and south-west, where the houses, especially those towards the north-east, are removed to a due distance from the influence of the marshy soil on the banks of the river. And here the general aspect of the town is splendid; the streets and squares arc all, without exception, spacious and elegant, not inferior to the finest squares of London, and amply supplied with every convenience suited to a town residence. In proceeding to the westward, or higher up the river, the general appearance of the city declines. The streets are less spacious, and the houses, though comfortable and in good repair, yet bear the marks of antiquity. Continuing further to the westward, the scene becomes gradually more unpleasing, until it terminates in that neglected portion of the metropolis usually denominated the *Liberty*, from its being without the jurisdiction of the Lord Mayor. Here, with the exception of some streets, which, though spacious, are irregular and inelegant, the houses are crowded together, with dirty back yards of small extent attached to some of them, while othershave no convenience of any kind. These streets are inhabited partly by shopkeepers or traders, but by far the greatest proportion of them are occupied by working manufacturers, petty retailers, labourers of the lowest condition, and beggars, who are crowded together in narrow lanes and alleys to a degree distressing to humanity. Those wretched habitations are let out in single apartments, at the rate of from one to two shillings *per* week, and to lighten this rent, two, three, and even four families become joint tenants. In one small house, from 30 to 50 individuals will be frequently found crowded together; and it is a well attested fact, that, some years past, one house in Braithwait Street contained 108 individuals. The nuisance and filth arising from this excessively crowded population, it is hardly possible to describe. At an early hour, from ten to sixteen persons may be seen in one of these rooms not fifteen feet square, stretched on filthy straw, swarming with vermin, and without any covering—save the wretched rags that constitute their wearing apparel. The landlords of these miserable tenements generally reside in a different part of the town. They seldom visit their tenants, but for the purpose of exacting the weekly rent, in which they betray no remissness. As to repairs, or whatever else may be required for the comfort of the inhabitants, they are totally indifferent; so that many of these habitations are in a state of decay, and totally unfit to afford the necessary shelter from the inclemencies of the weather. All these evils are aggravated by the various nuisances of slaughter-houses, soap manufactories, carrion-houses, &c. which are allowed to exist here; and by the numerous dram-shops which are established, and which necessarily lead to all sorts of immoralities and disorders.

Bay of Dublin.

The bay, at the head of which Dublin is situated, has been justly celebrated by all travellers. From this bay, there is so fine a view of the surrounding scenery, that it has been compared to the Bay of Naples. The entrance between Baily Point, in the peninsula of Howth, on the north, and Dalkey island on the south, is $6\frac{3}{4}$ English miles wide, and from the island to the point, the direction is N. $11^{0}\ 0'$ E. From the line uniting these points to the light-house at the end of the pier, the distance is $3\frac{3}{4}$ miles, and to Ringsend, at the mouth of the Liffey, $6\frac{3}{4}$ miles. The north entrance of the bay is bounded by the bold and elevated peninsula of Howth, which, with its two light-houses, forms an excellent land-mark both by night and by day. Here the eye is met by heath and rocks rudely intermingled, while among these wild objects a neat villa, with glittering white walls, placed in an apparently inaccessible situation, and having around it several spots of green pasture reclaimed from the surrounding waste, appears finely contrasted with the romantic wildness of the adjacent scenery. After passing the peninsula of Howth, the north shore of the bay is low; and is generally studded with white houses, either single or in groups, to the water's edge, whence a fine country is seen rising into gentle eminences, clothed with wood and interspersed with villas, till the view is lost in the distant horizon.

The southern point of entrance into the bay is formed by the rocky island of Dalkey, which is crowned by a martello tower, and separated from the continent by a deep navigable channel varying from 200 to 300 yards in breadth. Over the rocky bottom of this narrow channel, the tide rushes with an impetuosity, which, joined to the narrow entrance, will render it impossible, by any improvement, to make this a safe place of shelter for vessels in stormy weather. From Dalkey, farther into the bay, the coast is rocky and dangerous; there are several villages on it, however, such as Bullock,

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Dunleary, and Blackrock; behind which the eye wanders over a fine country, richly overspread with villas, woods, and pastures, and gradually rising by gentle eminences into the Wicklow mountains, which form, by their picturesque outline, a beautiful termination to the prospect. The only possible chance of accident in entering the bay of Dublin, arises from the sand called Kish, the north part of which lies about six miles NE. from Dalkey, and on which the Albion man-of-war formerly struck. The bottom of the bay is, throughout, of fine sand, and affords good anchorage, in from four fathoms, or not so much at low water, to a greater depth. With westerly winds, which blow from the shore, the water is of course smooth; from a northerly wind, the peninsula of Howth affords shelter, and from a south wind, the high grounds on the southern shore. But there is no shelter from easterly or south-easterly storms, which, during the winter months, frequently blow with tremendous fury into the bay. A vessel which happens at these times to be embayed while there is not sufficient water over the bar, must depend for safety solely on her anchor, and if this last hope fail, she can scarce avoid destruction on that immense extent of sands which encircle the bottom of the bay, and which have been the scene of numerous and fatal shipwrecks. These dangerous sand-banks, which extend over so large a space to the north and west of Dublin, are called the North and South Bulls. Between them lies the harbour. This is properly a continuation of the channel of the Liffey, which, when the tide is full, seemingly terminates at Ringsend, on the sea-shore, where the sand commences, but when the tide retires, the channel is seen to extend three miles and two hundred and eighty-six yards farther into the bay, having the sand-banks on each side. A harbour formed in this manner, of such precarious materials as the shifting sands of the ocean, liable to be driven from their position by every tempest or river-flood, which was besides narrow, irregular in its depth, of limited accommodation, entirely exposed to the prevailing winds, and of difficult entrance in consequence of its bar, could not be supposed adequate to the rising trade of a flourishing metropolis; and with the view, therefore, of correcting these natural defects, the most magnificent works have been projected and carried into effect by the spirited inhabitants of Dublin. The stream of the Liffey, as far as the sea-shore at Ringsend, was first confined by two walls, called the North and South Walls, already mentioned, and to secure the channel of the river from the inroads of the adjacent sands of the southern bank, called the South Bull, a vast work of frames and piles was carried along its edge to a distance into the sea of 7938 feet, or about one mile and a half. For this there was substituted, in 1755, a double stone wall, filled between with gravel, and forming an elevated walk, secured on both sides by parapet walls. The frame-work was afterwards carried out 9816 feet further to the eastern point of the bank, and, in consequence of the expence of keeping it in repair, a stone wall was substituted in its place, which was begun in 1761, and finished in 1768. This pier, which is the greatest work of the kind ever attempted in Britain, or perhaps in the world, is above three English miles in length. It consists of two parallel walls, constructed with large blocks of hewn granite, so dovetailed into each other, that no single block can be removed from the mass of which it forms a part without breaking it. The space between the two walls is filled with gravel and shingle to a certain height, over which is a course of masonry, and the whole is covered with granite blocks, generally from six to seven feet in length. The pier thus constructed forms a solid mass thirty-two feet in breadth at the bottom, and twenty-eight feet at the top, and it is terminated by a handsome circular light-house, which was finished in 1768. By means of these great works, the harbour is effectually secured against the adjacent sands of the South Bull, which are rapidly accumulating against its outer side, and have, in one place indeed, risen above it. To the northward, however, it is open to the encroachments of the sands from the North Bull; a projection from which, with a depth on it, at low-water of spring-tides, of only five feet, runs out in a south-west direction, and shoots athwart the harbour, forming a bar without the entrance two miles long by half a mile broad. This bar formerly extended to the South Bull; but at present it is separated from the latter by the south channel, about a quarter of a mile wide, and in which the least depth of water is eight feet. Various improvements have been suggested with the view of still farther securing the harbour, which continues exposed to the open swell of the sea in easterly storms. The object of these is chiefly to give shelter and smooth water, to deepen the channel for the lying of ships, to increase, in a certain degree, the current at the mouth of the harbour during the ebb-tide, and to direct it immediately against the bar, with a view of sweeping it in whole or in part away. The entrance is at present marked by the light-house on the south side, and, on the north, at the distance of a quarter of a mile, by the spit buoy, placed on a spit of sand projecting from the North Bull, which dries at the low-water of spring-tides. The plan proposed is to build a light-house at this buoy, and a pier commencing from the light-house, and carried to the north shore of the bay, so as to recede by a circular sweep from the pier on the south side as it approaches the shore; and thus to inclose within the harbour a great expanse of water, which, flowing out at the ebb through the contracted space between the two light-houses, must increase the action of the current against the bar, and must thus tend to sweep it away. The two light-houses also, by marking the channel more decidedly, will render stranger vessels less liable to fatal mistakes.

Harbour.

Supply of Water, Markets, &c.

For many years prior to the year 1806 the streets of Dublin were, in the essential points of paving, lighting, and cleansing, in a deplorable state. In these matters great improvements have been made by the commissioners appointed since that time, so that there is now little to complain of on the ground of these deficiencies. Additional supplies of water have been also introduced into the city from the Grand

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and Royal Canals, and metal pipes have been substituted in place of wooden ones. In the year 1816, the expences of the water establishment amounted to L. 21,000. The markets in Dublin are extremely convenient and well laid out, and they are abundantly supplied with cheap and excellent meat. But they are generally placed in low and confined situations, to which the access is narrow and dirty. Poultry and eggs are in great plenty, and the fish markets always contain an abundant supply, and in great variety. Roots and vegetables are also plentiful and of a good quality. Fruits are not so abundant in Dublin as in other places. Strawberries, however, form an exception, which are plentiful and of an excellent kind. Milk and butter bear a high price, and they are, as in all large capitals, frequently bad, more especially the first.

Charitable Institutions.

Dublin abounds beyond almost any other place in charitable institutions. For every infirmity to which the human frame is subject, whether bodily or mental, hospitals are established. Here are houses of asylum for age, sickness, and poverty; also for unemployed tradesmen, and for servants out of work. There are institutions for the employment of the industrious, as well as for the reformation of the profligate, of both sexes. Charitable associations exist under every modification, and societies without number for searching out objects of distress, and for relieving those who are ashamed to beg. Several charitable dispensaries have been begun, and institutions for diffusing among the poor the benefits of the vaccine. Of most of these institutions a general account will be found in the *Encyclopædia*. Many others have been lately begun, of which our limits can afford only a slight notice. St George's Dispensary, which annually relieves 5000 patients, and which has a connected fever hospital, was opened in 1801; and the North-west Dispensary, which annually relieves 3000 patients, in 1804. In 1814, an infirmary was begun for diseases in the eye, which, in nine months, afforded advice and assistance to 800 persons. The Dublin Female Penitentiary, directed by a committee of females, by whom it is daily visited, was established in 1813; also in 1809, an asylum was begun for infirm and aged female servants; in 1802, a house of refuge for servants out of place; and, in 1814, a temporary retreat for poor artisans out of employment. In 1813, a society was begun for the relief of poor debtors, and various charitable associations have of late years been instituted, generally for the relief of the industrious poor, while others have been confined to particular classes of trades and professions. In 1816, a society was founded for the instruction of young chimney sweeps, and for rescuing them from the tyranny of their masters.

Seminaries of Education, &c.

The institutions for the diffusion of instruction, whether moral or religious, are numerous. Schools abound of every description, and for every class of persons. There are also religious societies for every purpose, for distributing Bibles and religious tracts, as well as for discountenancing vice. The same zeal is also displayed for the advancement of literature, science, and the arts, and different institutions have been formed for these laudable objects. Of these may be mentioned, the Dublin Library Society, and the Dublin Institution, begun in 1811, to each of which libraries are attached. In the Dublin Institution lectures are now given on scientific subjects, to illustrate which by experiments, a philosophical apparatus has been procured. The Dublin Society also, originally instituted for the encouragement of agriculture, has considerably extended its plan; having established an excellent museum of natural history, and instituted professorships for different branches of science. This society removed in 1815 to the magnificent mansion formerly possessed by the Duke of Leinster.

Public Buildings.

The public buildings of Dublin are both magnificent and substantial. They have been mostly described in the *Enccylopædia*; but various alterations and improvements have since taken place. In 1815, the foundation stone was laid of a new post-office, the building of which has been carried on with great vigour. This spacious edifice is 223 feet in front, and 150 feet in depth; and it consists of three stories. In the centre is a grand portico 80 feet in length, consisting of a pediment supported by six pillars of the Ionic order, and surmounted by three beautiful statues. The estimated expence of this building is L. 50,000. The stamp-office has been transferred from the inconvenient house in Eustace Street, in which its business was formerly transacted, to the splendid mansion occupied by Lord Powerscourt, and the accommodation has been increased by an extensive wing which has been added at the back. The Dublin Penitentiary, begun in 1812, is a plain and substantial building, formed of hewn blocks of limestone, presenting a front of 700 feet. It is intended for the reformation of such convicts as are sentenced to transportation, who are placed in solitary confinement, and gradually restored to society as their conduct recommends them to favour. The expence of this edifice is estimated at L. 40,000. A new house of correction was also begun in 1813. This building, of which the expence is stated at L. 28,000, has a ponderous and gloomy aspect. The Richmond Lunatic Asylum, which was begun in 1810, was completed in 1815, at an expence of L. 50,000. This is a noble institution, and the regulations under which it is managed breathe a spirit of mildness and benevolence honourable to the humanity of their authors. To accommodate the increasing number of students at the university, it has been found necessary to erect a new and extensive range of apartments on the south side of the new square, which had not before been completed. This wing forms a new front to the college, 270 feet in breadth. It consists of four stories, containing thirty-two windows in each, and cost L. 26,000. The number of students at the university in 1817 was 1230. The old chapel for public worship at the castle having fallen into a ruinous condition, has been taken down, and a new edifice erected in its place, at an expence of L. 42,000. This chapel was opened for public worship on Christmas 1814. An elegant new church, for the accommodation of a Catholic congregation, was begun in the year 1816,

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of which the estimated expence is L. 50,000. The principal front extends 118 feet, and consists of a portico of six fluted columns of the Doric order. Over the entablature is a pediment ornamented with the figures of Faith, Hope, and Charity. The portico projects ten feet on an extended flight of steps, and beneath it are the three grand entrances for the congregation.

Great improvements have been of late made on the river Liffey, both in the formation of quays and in the construction of bridges. The old walls by which the river was embanked having fallen into ruin, it became necessary to rebuild them, and this work has been proceeded in with great vigour. The new walls which have been erected are faced with large blocks of hewn mountain granite, and huge blocks of the same material connect them with the quays, and give them stability; all the awkward buildings, wharfs, and warehouses, which interrupted the line of quays, on either side of the river, and projected into its channel, have been at the same time removed. The river Liffey is crossed by seven bridges, some of which are of recent construction, and an eighth is just begun. The foundation of Whitworth bridge was laid in 1816, in place of the one formerly known under the various names of the Old Bridge, Dublin Bridge, and Ormond Bridge, which was carried away in 1802. Richmond Bridge, which was begun in 1813, was opened to the public in 1816. It is 52 feet broad, and 220 long, and cost L. 25,800. Between this bridge and Essex Bridge, an iron bridge for foot passengers was opened in 1816. It is 140 feet long, and 12 feet wide, and cost L. 3000.

Population of Dublin in 1728, according to the most accurate computations - -	146,000
By an actual enumeration in 1798 - -	170,805
By the return to Parliament in 1814 -	175,319

See Whitelaw's *History of Dublin.* 2 vols. 4to. 1818. (O.)

Situation.

DUBLIN, a county of Ireland, situated between 53° 10′ and 53° 37′ N. Latitude, and between 6° 4′ and 6° 36′ W. longitude from Greenwich, is bounded on the north by the county of Meath; on the east by the Irish sea; on the south by Wicklow; and on the west by Meath and Kildare. It is about 30 English miles in length and 20 in breadth, and contains, according to Archer's *Survey*, 147,840 Irish, or nearly 240,000 English acres. Beaufort estimates its contents at 355 square miles, or 228,211 acres English, and Wakefield at 388 square miles. About an eighth of its area is occupied with mountains and wastes, a tenth with buildings, roads, rivers, &c. and the remainder is arable and pasture. It is divided into six baronies and a half; namely, Balruddery, Nethercross, Coolock, and Castleknock, on the north of the river Liffey, and Newcastle, Uppercross, and the half of Rathdown on the south,—the other half of Rathdown being in the county of Wicklow. The most fertile land is in the former baronies; great part of the latter, bordering on the county of Wicklow, is covered with heath, and rocky or mountainous. Dublin is in the province of Leinster; gives a title to an archbishop, whose jurisdiction also extends over the dioceses of Kildare, Ferns and Leighlin united, and Ossory; and contains 107 parishes, of which 20 are in the city of Dublin, provided with rectors or vicars, and forty-six curates.

Extent.

Divisions.

Climate.

The prevailing wind is from the south-west, from which and from the other western points it blows for nearly two-thirds of the year. The north-west wind also is more frequent here than in England, and the north, east, and north-east less so; but easterly winds are common in the spring months, and often check vegetation. Storms, chiefly from the SW. and W. are more frequent than in England. According to a register kept at the botanic gardens near Dublin, the quantity of rain in the year, from 1802 to 1811 inclusive, varied from 18.970 to 29.720 inches. The range of the barometer is about $2\frac{4}{10}$ inches. The medium heat for five years ending with 1800 was 50° 15′, the maximum 81.50, and the minimum 14.50. The yearly number of fair days at Dublin, for 12 years from 1791 to 1802 inclusive, was from 168 to 205, the average number being 179.

Soil and Surface.

The soil of this county is generally shallow, and the substratum almost universally a cold clay. There is very little turf bog in the northern parts, but some considerable tracts among the mountains in the south. The face of the country does not exhibit much diversity of prospect; but from the hill of Howth, a little to the north-east of the city, there is a very extensive view, embracing the bay of Dublin and the city itself, and a number of villages and country seats around it, with the Wicklow mountains on the south, the bases of which are studded with numerous villas, and the ocean on the east. The Phœnix Park, the country seat of the Lord Lieutenant, stands on the banks of the Liffey, west from the city. In this county, as in many parts of Ireland, there is a want of trees to add to the beauty of the landscape.

Minerals, &c.

No minerals or fossils of much value have been discovered, or are now worked. To the south of the city are some good quarries of freestone; limestone, and limestone gravel, abound in various parts. At Lucan, about eight miles from the city, there is a mineral spring which is much frequented in summer. The water is sulphureous, resembling that of Aix-la-Chapelle and Bruges, but with this difference, that the Lucan water is cold, whereas that of the above two places is hot. The principal river is the Liffey, which flows through the middle of the county from west to east, and falls into the bay of Dublin. It is navigable for large vessels up to the new custom-house at Carlisle bridge, where spring tides rise about 13 feet, and for boats as far as Chapel-izod, about four miles above Dublin castle. The only other river worthy of notice is the *Dodder*, which, rising in the northern mountains, discharges itself into the bay of Dublin at Ringsend, a little below the city.

Estates and Farms.

Landed property in this county is a much more marketable commodity than in most other districts of Ireland. There are here no large territorial domains.

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Leases vary in their terms, but commonly include a life, for the purpose of creating a vote. Farms are in general very small near the city, seldom more than 20 or 30 acres, but at a distance from 50 to 150 acres. The farm buildings are for the most part very insufficient. Near the city the fences are of white thorn, but in the remote parts they are nothing more than a bank and ditch. Lime, limestone gravel, and marl, are used as manures. The city of Dublin might afford the means of enriching a tract of several miles around it, but its street dung is so little valued, that it is sometimes brought to Scotland by coasting vessels as ballast, and much of it is thrown into the Liffey. Except in the vicinity of the city, the demands of which regulate the species of crops cultivated, the agriculture of this county does not differ materially from that of the Irish counties we have already described. Two crops of wheat in succession, and after these two of oats, without fallow or green crop, are frequently taken, according to Archer. Barley is not cultivated extensively. The natural pastures are, with few exceptions, of an inferior quality. There are few or no flocks of sheep in the possession of farmers. In the city, and within four miles of it, about 1600 cows were kept in May 1801, according to Archer, where there were formerly near 7000. The old Irish breed of cows is almost extinct, and their place is supplied by the short horns and other breeds from England. In 1801, the tithe throughout the county was for wheat from 7s. to 10s.; barley 6s. to 8s.; Oats 5s. to 7s.; and hay 2s. 6d. to 10s. *per* acre.

Agriculture.

Manufactures.

The manufactures of this county are not of great importance in a national point of view. A strong kind of dowlas, and some sheetings, with a few other articles, comprise all the branches of its linen manufacture. A number of hands are employed in making broadcloths, cottons, silks, stockings, glass, and the coarser sorts of hardware, though none of the works are upon a very large scale.

Commerce.

The trade of the county, and of a great part of Ireland, necessarily centres in Dublin, the capital. Two canals afford a ready communication between the city and the interior of the country. The grand canal runs from Dublin to the river Shannon, at Banagher, 63 miles; while a branch proceeds southward till it meets the river Barrow at Athy, 43 miles from Dublin. The royal canal, which leaves Dublin to the north of the former, is to join the Shannon at Tarmonbarry, 60 miles from Dublin. It is now nearly finished. Passage-boats ply from Dublin to within nine miles of Tarmonbarry. The affairs of the original company having got into disorder, it was dissolved by an act of the 53d of the King, and their whole property vested in trustees, who are the directors general of inland navigation. Great expence has been incurred in attempts to improve the harbour of Dublin; but the shifting sands by which it is incommoded, have rendered them in a great measure unsuccessful. Yet Dublin enjoys an extensive commerce with the colonies, with the continent of Europe, particularly Spain and Portugal, and with America. Its corn trade has increased from L. 233,069 in 1785, to L. 860,165 in 1811; and in the provision trade it seems to be gaining both upon Cork and Limerick.

Fisheries.

The fish found in the rivers of this county are salmon, pike, and eels. There is a considerable salmon fishery on the Liffey, which, in 1801, gave employment to eighteen men from January to Michaelmas. During the season, from 90 to 200 were caught every week. There is a fine salmon leap at the town of Leixlip. The eels are of two kinds; the silver eel, so called from the whiteness of its colour, is exceedingly abundant in Tullagheen river, and near Fieldstown; and the sand eel, which is frequent in the loose sand near the sea coast. In 1801, 87 wherries belonged to the county, each carrying seven or eight hands, and receiving a bounty of 20s. a ton, which were employed in catching cod, ling, haddock, ray, herrings, &c. There were about 20 smacks, and five seine nets employed in the salmon fishery between the bay of Dublin and Dunleary; which, with many small boats, engaged in the herring fishery at the proper season. At Dunleary there were also eleven yawls, and at Bullock seven, engaged in fishing for whiting, pollock, and herrings. The shad and the sprat have been found in the Liffey, and the sturgeon in the bay of Dublin. Near the city, there are both natural and artificial beds of oysters; some of them in the latter as large as a horse-shoe. Porpoises are often found on the coast.

Weights and Measures.

The avoirdupois weight is in general use for all sorts of grain, groceries, provisions, &c. With grain of every denomination weight is assigned for measure. The barrel of wheat, peas and beans, and potatoes, must weigh 20 stone, barley 16, oats 14, and malt 10 stone. Rough tallow from the butcher is sold by the stone of 15 lb.; wool by the stone of 16 lb.; and hay by the load of 4 cwt. The barrel of lime is 40 gallons of $217\frac{6}{10}$ cubic inches; and the half barrel of coals 20 gallons Winchester.

Towns.

In Archer's Survey, no fewer than 79 towns and villages are mentioned, besides the city of Dublin. Of these the most considerable are Balbriggen, Black Rock, Chapel-izod, Clontarf, Dunleary, Finglass, Glassnevin, Howth, Leixlip, Lucan, Mallahide, Rathfarnham, Rush, Skerries, Swords, and Tallagh.

Representation.

The county, the city, and the university of Dublin, with the boroughs of Newcastle and Swords, returned ten members to the Irish Parliament; the county now sends two, the city two, and the university one, to the Parliament of the United Kingdom.

The cabins, fuel, food, and clothes of the lower classes in the country, are not materially different from what they are in the Irish counties already described, except that fuel is very scarce, and cabins near the city are high rented. Turf bog is of small extent in most parts of it; and coals, which are brought from the opposite coasts of England and Scotland for the supply of the city, are too dear for the cottager and small farmer.

Wages and Prices.

In 1801, the wages of common labour were from 8s. to 9s. a-week; while oatmeal was 4s. 8d., and potatoes 1s. 9d. *per* stone. In 1811, wages were nearly the same; but oatmeal was 3s., and potatoes 6d. *per* stone. As these two articles form almost the only food of the

lower classes, their price, when compared with the rate of wages, affords a rule for estimating the condition of the great body of the people.

Population.

The population of the county in 1792, according to Beaufort, was 54,000; and of the city 144,000. Whitelaw makes the population of the city in 1798 amount to 172,091, and the number of houses to be 16,401; but by an enumeration in 1804, the houses were found to be less by 756, and the inhabitants by 4192. By a census taken in 1813, the population of the whole county appears to be 208,000, and the number of houses 26,000. According to Wakefield, the Catholics are to the Protestants as six to one. Few of the officers of the militia are Catholics; but many of the privates. On the grand juries the proportion of Catholics is small; in some instances none are called. The use of the English language is universal, and few can speak Irish.

See the Works of Beaufort, Newenham, and Wakefield, as quoted under the preceding counties of Ireland; Rutty's *Natural History of the County of Dublin*, 1772; Young's *Tour in Ireland in* 1779; Archer's *Statistical Survey of the County of Dublin*, 1801; Dutton's *Remarks on Archer's Survey;* and the article DUBLIN in the body of the work. (A.)

DUCLOS (CHARLES PINEAU), a French author of some celebrity, was born at Dinant in Bretagne, in the year 1704. At an early age he was sent to study at Paris. The imprudence of youth, and his love of pleasure, led him, at first, to contract certain intimacies which were little suited to his circumstances; but having afterwards disengaged himself from these, he courted the society of all the wits of his time, by whom he was well received. He became a member of that club, or association of young men, who published their juvenile productions under the titles of *Recueil de ces Messieurs*, *Etrennes de la St Jean*, *Œufs de Paques*, &c. The romance of *Acajou* and *Zirphile,* which was composed after a series of plates which had been engraved for another work, was one of the fruits of this association, and was produced in consequence of a sort of wager among its members. The epistolary dedication to the public, which was prefixed to this trifle, gave umbrage to some, in consequence of the flippant tone which the author assumed. Duclos had previously written two other romances, which were more favourably received: *The Baroness de Luz*, and the *Confessions of the Count de ****. His first serious publication was the *History of Louis XI.* The style of this work is dry and epigrammatical; but the author has displayed in it considerable powers of research, and preserved the character of an impartial historian. The reputation of Duclos, as an author, was confirmed by the publication of his *Considerations sur les Mœurs;* a work which is much praised by La Harpe, and not without justice; for although the style, as in most of the writings of this author, is rather stiff and sententious, the book undoubtedly contains a great deal of just and ingenious reflection. It was translated both into English and German. The *Memoires pour servir a l'histoire du* 18. *Siècle*, which were intended by the author as a sort of sequel to the preceding work, are nevertheless much inferior, both in respect to style and matter; and are, in reality, little better than a kind of romance. In consequence of his *History of Louis XI.* he was appointed historiographer of France, when that place became vacant on Voltaire's retirement to Prussia. His *Secret Memoirs of the Reign of Louis XIV. and of Louis XV.*, and his *Considerations on Italy*, were not published until after the Revolution. The former work is highly spoken of by Chamfort.

Duclos became a member of the Academy of Inscriptions in 1739; and of the French Academy in 1747. Of the latter he was appointed perpetual secretary in 1755. Both of these academies were indebted to him, not only for many valuable contributions, but likewise for several useful regulations and improvements. As a member of the Academy of Inscriptions, he composed several memoirs on the Druids; on the origin and revolutions of the Celtic and French languages; on trial by battle, and proof by ordeal; scenic representations, and the ancient drama. As a member of the French Academy, he assisted in compiling the new edition of the *Dictionary,* which was published in 1762; and he made some just and philosophical remarks on the Port Royal Grammar. On several occasions, he resolutely supported the honour and prerogatives of the societies to which he belonged, and maintained the respectability of the literary character in general. He used to say of himself: "I shall leave behind me a name dear to literary men." His fellow citizens, whose interests he always supported with zeal, appointed him Mayor of their town in 1744, although he was resident at Paris. He was afterwards elected deputy from the commons, to the assembly of the states of Bretagne; and upon the requisition of this body, the king granted him letters of nobility.

In 1766, he was advised to retire from France, for some time, in order that the government might have an opportunity of forgetting some opinions which he had hazarded, on the subject of the dispute between the Duc d'Aiguillon and M. de la Chalotais, the friend and countryman of Duclos. Accordingly he set out for Italy, and, on his return, he wrote an account of his travels, which is also praised by Chamfort. He died at Paris, on the 26th of March 1772, in the sixty-ninth year of his age.

The character of Duclos, although it exhibited many singular traits, was still respectable, whether we consider him as a man or as an author. Rousseau described him, very laconically, as a man *droit et adroit.* In his manners he displayed a sort of bluntness in society, which frequently rendered him disagreeable; and his caustic wit, on many occasions, created enemies. To those who knew him, however, he was a pleasant companion. He was a great lover of anecdotes, and had the talent of relating them in a very agreeable manner. A considerable number of his good sayings have been preserved by his biographers.

A complete edition of the works of Duclos was published by Desessarts, in 10 vols. 8vo. Paris, 1806. See *Biog. Universelle.* (H.)

DUHAMEL, DE VRIGNY LE MONCEAU (HENRY LEWIS), author of many valuable works on Agriculture, Natural History, and the Arts; son of Alex-

Duhamel. ander du Hamel, lord of Denainvilliers, and of Ann Trottier, was born at Paris in 1700. His family had formerly emigrated to Holland, but returned to France as early as the year 1400, with the Duke of Burgundy.

He was educated at the College d'Harcourt; but the chief advantage that he derived from his residence there, was a taste for the further acquirement of physical knowledge, which he afterwards pursued with ardour at the Jardin du Roi, having for his fellow students a number of young men, who afterwards acquired a high degree of celebrity, and among the rest Dufay, Geoffroi, Léméri, Jussieu, and Vaillant. At the age of twenty-eight he obtained the title of Adjunct Botanist in the Academy of Sciences; in 1730 he became an Associate, and in 1738 an Academician, having previously been elected a Fellow of the Royal Society of London, in the beginning of 1734. Upon his first admission into the list of the Academy, his assistance was requested in the investigation of a disease which affected the saffron, cultivated in the Gâtinois, where his estate was situated; and he found reason to attribute it to a parasitical fungus attached to the roots of the plant. His memoirs and notes communicated to the Academy, as well as his separate publications, are so multitudinous, that the shortest possible enumeration of their subjects can barely be brought within the ordinary limits of a biographical article.

(1.) *A Disease of Plants*, Acad. Paris, 1728. (2.) *The Multiplication of Fruits*, 1728. (3.) *The Growth of Plants*, 1729. (4.) *Grafting*, 1730. (5.) *The Pear Tree*, 1730–1–2. (6.) *Soluble Tartar*, 1732–3. (7.) *Ether*, 1734. (8.) *Salt of Sulphur*, 1734. (9.) *Sal Ammoniac*, 3 parts, 1735. (10.) *The Purple Dye*, 1736. (11.) *The Base of Sea Salt*, 1736. (12.) *The Strata of Wood*, 1737. (13.) *Frosts*, 1737. (14.) *Bones Tinged Red*, 1739. (15.) *Polygala as a Pectoral*, 1739. (16.) *The Misletoe*, 1740. (17.) *Botanico-meteorological Observations*, continued annually for 42 years, 1740..1781. (18.) *The Union of Fractured Bones*, 2 parts, 1741. (19.) *The Strength of Timber*, 1742. (20.) *The Growth of Bones*, 5 parts, 1742–3. (21.) *Frobenius's Ether*, 1742. (22.) *Anatomy*, 1743. (23.) *Slips, Layers, and Offsets*, 1744. (24.) *Moisture in Oak Timber*, 1744. (25.) *A Magnetic Ore*, 1745. (26.) *The Preservation of Seed*, 1745. (27.) *Magnetising a Bar*, 1745. (28.) *Cordage*, 1746. (29.) *The Wounds of Trees*, 1746. (30.) *Lime*, 1747. (31.) *Calcination of a Stone*, 1748. (32.) *Ventilation*, 1748. (33.) *Plants raised in Water*, 1748. (34.) *Gunpowder*, 1750. (35.) *The Weight of Ignited Metals*, 1750. (36.) *Tull's Agriculture*, 1750. (37.) *The Compass*, 1750. (38.) *The Strata of Trees*, 1751. (39.) *The Growth of Horns*, 1751. (40.) *Bees*, 1754. (41.) *Madder*, 1757. (42.) *Spontaneous Combustions*, 1757. (43.) *Ergot*, 1759. (44.) *An Insect Devouring Corn*, 1761; and separately, 12, Paris, 1762. (45.) *A Descent of the Barometer*, 1763. (46.) *The Tea Plant in Sweden*, 1763. (47.) *Inflammable Vapours*, 1763. (48.) *Salts in Ashes*, 2 parts, 1767. (49.) *Overdriving Animals*, 1768. (50.) *Rhubarb*, 1768. (51.) *Hair Returning after 50 Years*, 1770. (52.) *A Change of the Needle*, 1771. (53.) *Variation Compasses*, 1772. (54.) *A Monstrous Apple Tree*, 1775. (55.) *The Management of Prisons*, 1780. Duhamel.

(56.) *Observations and Experiments with Madder Root, which has the Faculty of Tinging the Bones of Living Animals of a Red Colour. Phil. Trans.* XLI. 1740, p. 390.

(57.) *Traité de la Culture des Terres.* 6 v. 12. Par. 1750. Ac. Par. 1755–7.

(58.) *Architecture Navale*, 4. Par. 1752, 1758. Ac. Par. 1752. *Avis pour le Transport par mer des Arbres*, 2d edit. 12. Par. 1753.

(59.) *Conservation des Grains*, 12. Par. 1753, 1754, 1768. *Supplément.* Par. 1765, 1771. Ac. Par. 1765.

(60.) *Fabrique des Manœuvres pour les Vaisseaux.* 4. Par. 1757.

(61.) *Traité des Bois et Forêts.* 8 v. 4. Par. 1755...1767. Arbres et Arbustes, 2 v. 1755. Physique des Arbres, 2 v. 1758. Semis et Plantations, 1760. Exploitation, 2 v. 1764. Transport, Conservation, et Force, 1767. Ac. Par. 1755, 1758, 1760, 1767, 1768.

(62.) *Moyen de Conserver la Santé aux Equipages.* 12. Par. 1759. Ac. Par. 1755, 1758, 1759, 1760.

(63.) *Traité des Arbres Fruitiers.* 2 v. 4. Ac. Par. 1768.

(64.) *Traité des Pêches*, 1769... Jointly with M. de la Marre. Ac. Par. 1769.

(65.) Art *du Charbonnier.* Par. fol. Noticed Ac. Par. 1761. (66.) *De la Fabrique des Ancres*, 1761. (67.) *Du Chandelier*, 1761. (68.) *De l'Epinglier*, 1761. (69.) *De Reduire le Fer en Fil*, 1768. (70.) *Du Cirier*, 1762. (71.) *De Faire les Enclumes*, 1762. (72.) *Du Cartier*, 1762. (73.) *De Rafiner le Sucre*, 1764. (74.) *Du Drapier*, 1765. (75.) *De Faire les Tapis.* (76.) *De Friser les Etoffes*, 1766. (77.) *Du Couvreur*, 1766. (78.) *Du Tuilier Briquetier.* (79.) *Du Serrurier*, 1768. (80.) *De Préparer le Colle.* (81.) *De Faire les Pipes*, 1772. (82.) *Du Potier de Terre*, 1774. (83.) *Du Savonnier*, 1775.

The earliest part of Mr Duhamel's life was chiefly devoted to the study of vegetable physiology, which he had continued for thirty years before the publication of his principal works. The most original of his observations related to the growth of plants, the formation of the bark and the wood, the effects of grafting, the inversion of a tree, the double motion of the sap, and the influence of light, air, and soil. In agriculture, he introduced the practice of drying corn, in a particular stove or kiln, with a heat sufficient to destroy the insects which infested it and their larvas. He made many experiments on manures, and he conferred a great benefit on several provinces of France, by introducing the cultivation of potatoes into general practice, as well as by promoting that of rhubarb in different places.

Having obtained from Mr Maurepas the appointment of Inspector General of the Marine, he undertook to make himself master of every department of nautical knowledge; and setting out with the established doctrines of Euler and Bouguer, where theory was wanted, he collected, for his works on these subjects, an immense mass of facts and experiments, affording the means of resolving every question on practical grounds. He established a school for ship-

Duhamel.

builders, which effectually secured to them an education superior to that of simple carpenters. He also made some very valuable improvements in the theory of ropemaking, showing especially the disadvantages arising from the excessive twisting of cordage. His conduct in this capacity seems to have been as judicious in a moral as in a mechanical point of view; by his modesty and good nature, he silenced the contending passions of those with whom he was obliged to enter into discussion, and he was enabled to unite a variety of opposite interests, in the important object of the establishment of an academy, for the cultivation of naval science.

His meteorological observations included, besides the usual registers, accounts of the direction of the magnetic needle, of the state of agriculture, of the diseases of the year, and of the times of migration of birds, and of the appearance of their young.

From his experiments on the growth of the bones, he inferred, that they are enlarged by means of the ossification of the laminæ of the periosteum, nearly in the same manner as trees are known to grow by the hardening of the cortical layers; although the bones, while they are soft, expand in every direction, as the very young shoots of vegetables are also found to do. Having learned from Sir Hans Sloane, that madder possesses the property of giving colour to the bones, he fed animals successively on food mixed and not mixed with madder; and he found that their bones, in general, exhibited concentric strata of red and white; while the softer parts showed, in the mean time, signs of having been progressively extended. These experiments are still of great importance in illustrating the physiology of ossification, although the actual conversion of the periosteum into bone may justly be disputed.

In trees, Mr Duhamel found that the graft was incorporated with the stock, so as to form a single substance completely identical with it; and he showed that animal bodies were capable of a similar union, the vessels of the animals forming communications with those of the parts inserted; the spur of a cock, for instance, grafted into his comb, uniting perfectly with it, and becoming gradually furnished with a bony core, like the horn of a bullock, which either forms a joint with the cranium, or is firmly attached to it, and affords nourishment for the growth of this newly adopted member.

Having demonstrated, in 1737, the different natures of soda and potass, he made an interesting experiment on the production of these alkalis by different vegetables. He sowed the head of the salsola kali at Denainvilliers, and it was found by the analysis of Mr Cadet, that its ashes produced at first soda, but afterwards more and more potass every year; and, after several generations, almost entirely potass. His other chemical memoirs were of less permanent importance; and, with respect to the weight of ignited iron, he was unfortunately inaccurate in his mode of conducting the experiment, otherwise it must necessarily have led him to an anticipation of some of the most important discoveries of the last century.

From his extensive correspondence in different countries, he was enabled to communicate to the Academy, from time to time, a number of detached facts, which were both amusing and instructive; and which appear perpetually in the histories of the respective years. His works were in general of an elementary nature, and calculated for the use of such as possessed but little previous information; and, hence, they may appear to some readers to contain an unnecessary detail of explanation. "Prolixity," says Mr Cordorcet, "is injurious to perspicuity, when we are addressing ourselves to persons accustomed to fix their attention firmly on the subject before them; who are able to observe the slightest shades of difference, and to receive at once a variety of ideas; supplying, where there is occasion, any connecting links of the chain which may have been omitted: if we are too diffuse, the attention of such persons droops for want of excitement; their memory is fatigued with the attempt to retain impressions, which have not been communicated to them with sufficient force; and when they are compelled to travel slowly, the delay exhausts them, from having been in the constant habit of a more rapid motion. But it was not for this very limited class of readers that Mr Duhamel's works were calculated. He wrote for the use of those who seldom go beyond the bare expressions of the author; who find all close attention toilsome, and who read rather for simple information, than for the cultivation of the mind; and an author may always be said to write well, when his style is appropriate to his subject, and to the capacity of his readers."

Mr Duhamel was economical in his habits of life, and disinterested in his views; sacrificing his own pecuniary advantage, and that of his family, to the desire of serving the public by his experiments and his writings. Having onee established a certain scale for his expences, he never troubled himself with keeping a minute account of them. His integrity sometimes wore the appearance of severity, and his vivacity that of harshness; but no imputation was ever cast on the goodness of his heart. He was averse to all changes, both in political and scientific institutions, which were not connected with obvious improvement. He was punctual in his attention to the duties which his religion imposed on him, but he did not sacrifice to unnecessary parade, such of his hours as he thought might be more conscientiously employed in studies of general utility. His application, though assiduous, was seldom severely laborious. He never entered into any matrimonial engagements. On some occasions he felt himself neglected by the public; but he was little disposed to lament this injustice, except from reflecting on the effect, which it would have had on an individual less zealous, or less independent, than himself. Besides his election as a Fellow of the Royal Society of London, he obtained the honour of diplomas from the academies of Petersburg, Palermo, Bologna, Edinburgh, and Padua, and from several agricultural societies; and his name has acquired a celebrity commensurate to the extent of his varied researches.

Few persons have ever passed through life with greater tranquillity of mind, or with a greater desire of rendering themselves useful to mankind, than Mr

Duhamel || Dumarsais.

Duhamel. He was one of the most active promoters of the kind of revolution which took place in the cultivation of science during the last century; and of which the characteristic distinction was, to endeavour to turn its chief course towards the grand objects of public utility and domestic convenience. Upon this modification of the pursuits of natural philosophy, Mr Condorcet very judiciously remarks, that, "if the sciences have sometimes raised themselves too high towards heaven, and if it has been of advantage to recall them towards the earth, we must still shun the opposite error of condemning them to creep on it for ever:" and when we see the paths of discovery open before us, we must follow boldly wherever they lead us; confident that, sooner or later, all theoretical knowledge may eventually confer some material benefit on society, even with regard to the more practical purposes of life. Mr Duhamel, indeed, well knew the necessity of previous study, and of extensive inquiry, for the success of his experimental investigations: and the former half of a long life he spent chiefly in qualifying himself for making the observations, which he recorded, and deriving from them the instructions, which he published, in the latter. At a very advanced age, his memory began to fail; he still continued his pursuits, but without reaping any advantage from his application; he attended the meetings of the Academy, but took little or no interest in any thing that passed at them; and after having been present at one of these meetings, on the 22d of July 1782, he had an attack of apoplexy, which wholly deprived him of his remaining faculties, and on the 13th of August put an end to his life.

A few years before his death, he had felt very severely the loss of his brother, who had lived constantly at Denainvilliers, and had assisted him in many of his agricultural researches and meteorological observations, though he had always remained anonymous. His nephew, Mr Fougeroux, had also been useful to him, on several occasions, in his literary pursuits; and this gentleman became heir to the principal part of the property of both his uncles. *Eloge*, by Condorcet, *Hist. Ac. Par.* 1782, p. 131. (A. L.)

DUMARSAIS (Cesar Chesnau), a French writer who distinguished himself as a philosophical grammarian, was born at Marseilles on the 7th of July 1676. His life consisted of a succession of misfortunes; and his merits, considerable as they were, seem to have been entirely overlooked and neglected by his contemporaries. His father died while he was yet an infant; and his mother, by her extravagance, dissipated his patrimony. He was educated in his native town by the Fathers de l'Oratoire, into whose congregation he entered, but left them at the age of twenty-five, and repaired to Paris, where he married, and was admitted an advocate in 1704. He soon, however, quitted the bar; separated from his wife, to whom he gave up the little he possessed, and went to reside with the President de Maisons, in the capacity of tutor to his son. But his prospects in this quarter were blasted by the death of his patron; by whose family he was not treated with that respect and gratitude which were due to his talents and his services. He was afterwards, successively, tutor to the son of Law, the famous projector, and of the Marquis de Beaufremont. It was during this last period that he published the results of his grammatical investigations, which were received with great coldness. At a subsequent period, he opened an establishment for education in the suburb St Victor, which scarcely afforded him the means of subsistence; and he expired, at length, under the accumulated pressure of years, infirmities, poverty, and neglect, on the 11th of June 1756, at the age of eighty.

Dumarsais || Dumfries.

Dumarsais possessed no ordinary talents. His researches are distinguished alike by their accuracy, ingenuity, and depth. As a man, he combined the greatest purity of morals and simplicity of character with a rare degree of manly fortitude in the midst of his misfortunes. Yet, during the greater part of his life, he was left to languish in obscurity; and his merits scarcely attracted any notice until nearly half a century after his death. His works on philosophy and general grammar, however, are worthy of attention. Of these, the best is his *Treatise on Tropes or Figures*. D'Alembert and Voltaire have both paid a just and discriminating tribute to the merits of Dumarsais. An edition of his works was collected by Duchosal and Millon, and published at Paris, in 1797, in seven vols. 8vo.

In the year 1804, the French Institute proposed a prize for an *Eloge* on Dumarsais, which was gained by M. Degerando, whose work was published at Paris, 1805, in 8vo. A previous, and well written *Eloge* on the same author, by D'Alembert, is to be found in the *Melanges de Litterature*, and prefixed to the above-mentioned edition of the *Works of* Dumarsais. See also *Biog. Universelle*. (H.)

DUMFRIES, a county of Scotland, situated between 55° 2′ and 55° 31′ N. Lat. and between 2° 39′ and 3° 53′ W. Long. is bounded on the north by the counties of Lanark, Peebles, and Selkirk; on the east by Roxburghshire, and Cumberland in England; on the south by the Solway Frith; and on the west by the stewartry of Kirkcudbright, and the county of Ayr. Its greatest length, in a south-east direction, is about 50 miles; and from Peebles-shire on the north, to the Solway Frith on the south, the distance is about 32 miles; but the boundaries are very irregular. It contains somewhat more than 1006 square miles, or 644,385 English acres, of which about 86 miles are in general low arable land, lying on the sea coast, 322 miles chiefly hilly, and 598 mountainous. It was anciently divided into three districts, Annandale, Eskdale, and Nithsdale, so named after its principal rivers, each under a separate jurisdiction; and these names are still retained in the common language of the people. Within the limits of the county there are 42 parishes, and 43 officiating clergymen. These are under the ecclesiastical jurisdiction of the synod of Dumfries, which extends over five presbyteries, and fifty-three parishes.

Situation. Extent. Divisions.

This county has for the most part a southern exposure, and, being surrounded by vast ranges of mountains on the north, east, and west, the climate, though moist, is mild and salubrious. Snow seldom

Surface, &c.

Dumfries.

remains long, even on the declivities of the mountains. The average annual temperature is about 45°. The winds in summer and harvest are from the west and south, and in winter and spring from the east and north. About one acre in a hundred may be under wood; but it is not sufficient either for shelter or ornament. The soils are gravel or sand, loam, and clay, with moor and moss in some places, and alluvial tracts on the banks of the rivers and the Solway Frith.

Rivers and Lakes.

The principal rivers are the Nith, the Annan, and the Esk. The Nith, after entering the county from Ayrshire, traverses it in a south by east direction, for more than 40 miles, and, passing by the town of Dumfries, falls into the Solway Frith. Annan, the central river, has its source in the mountains in the north, where the county is bounded by Lanark and Peebles, and near which the rivers Clyde and Tweed also take their rise, and, flowing south by Moffat, discharges itself into the Solway Frith below Annan, after a course of about 30 miles. The Esk rises in the mountains on the borders of Selkirkshire, and, after flowing past Langholm, it forms for a mile the boundary with Cumberland, which it then enters, and, passing by Longtown, falls also into the Solway Frith, the whole extent of its course being above 40 miles. Over the Nith, and within this county, there are six bridges, five over the Annan, and as many over the Esk. The bridge over the Nith at Dumfries was built in the middle of the thirteenth century. A number of tributary streams join these rivers in their progress. Of the lakes, Loch Skeen, 1300 feet above the level of the sea, is most worthy of notice. It feeds the well known cascade, called the *Gray Mare's Tail*, near the head of Moffat Water. Near Lochmaben there are six or seven lakes; the ancient royal castle of that name is situate on the margin of one that is three miles in circumference.

Minerals.

The minerals and fossils of Dumfries-shire are lead, antimony, manganese, coal, sandstone, iron in different forms, limestone, marble, and slate; and gold in small quantities is still occasionally found in the sand, or adhering to quartz, near Leadhills. The lead-mines at Wanlockhead belong to the Marquis of Queensberry, and yield him about L. 5000 a-year. In 1809, their produce was 15,552 bars, of 9 stones each, worth L. 32 *per* ton. Silver is sometimes extracted from the lead, in the proportion of from 6 to 12 ounces in the ton. About 300 people are employed, of which 118 are pickmen, who earn about L. 32 a-year, working six hours out of the twenty-four. There is a library of 700 volumes, accessible to the workmen for a small payment; and they are distinguished for their information and good conduct. The only coal capable of being wrought is at the extremities of the county,—Sanquhar on the north-west, and Canobie on the south-east; so that the greater part of it is supplied with this article from England, and from Lanarkshire and Ayrshire. The principal limeworks are at Closeburn in Nithsdale, and Kelhead in Annandale.

Mineral Waters.

Mineral waters are found in different parts of the county, particularly a fine chalybeate, near the burgh of Annan; another at Brow, in the parish of Ruthwell; and a sulphureous spring at Closeburn House. But the two most esteemed are near Moffat, one of which is sulphureous, and the other a chalybeate. The former, which has been known for two centuries, is about a mile from the village; and issues from a rock of compact greywacke, which contains interspersed iron pyrites; and a little above it there is a bog. Dr Garnet found a wine gallon of it to contain of muriate of soda 36 grains, sulphureted hydrogen gas 10 cubic inches, azotic gas 4 inches, and carbonic acid 5 inches. In its taste and medicinal qualities it is similar to the sulphureous waters of Harrowgate, only less powerful. It is commonly drank at the fountain, and also used for the warm bath. The chalybeate, or Hartfell Spa, is about five miles from the village, in a deep and sequestered ravine, on the side of the Hartfell mountain, and contains, according to Dr Garnet's analysis—of sulphate of iron 84 grains, sulphate of alumina 12, oxide of iron 15, and 5 inches of azotic gas, in a wine gallon. It is strongest after rain. It is a powerful tonic, taken at the rate of a wine glassful twice or thrice a-day; and may be carried to any distance. This spring was discovered about 70 years ago.

Landed Property.

The most extensive proprietors in this county are the Duke of Buccleuch, the Marquis of Queensberry, the Earl of Hopetoun, and the Earl of Mansfield; and besides these, the number of proprietors is about 460. The valued rent is L. 158,502, 10s. Scots, of which more than a half is held under entail. In 1811 the real rent of the lands was L. 246,001, 12s. 6d. or about 7s. 6d. the English acre, and of the houses L. 16,787 Sterling. In the vicinity of the castle of Lochmaben, a considerable tract of rich land, called the *Four-towns*, is held by what is termed the *kindly tenure*, the only instance of the kind perhaps in Scotland. The land is parcelled out in lots among a great number of proprietors, who pay a small fixed sum yearly, in full of rent-duty and tithe, to Lord Mansfield, as keeper of his Majesty's castle of Lochmaben; and they transmit their shares simply by possession. This peculiar tenure is said to be as ancient as the time of Robert Bruce. Many of the lots are too small to afford their owners the means of subsistence. The principal seats are Drumlanrig Castle, on the west bank of the Nith, now the property of the Duke of Buccleuch; Raehills, built by the late Earl of Hopetoun, on the old family estate of Annandale; and Langholm Lodge on the Esk, the occasional residence of the Duke of Buccleuch. Caerlaverock, near the Solway Frith, the seat of the Lords Maxwell; Mortoun Castle, Torthorwald, and Sanquhar Castle in Nithsdale; Achincass, Lochwood, Lochmaben, and Comlongan, in Annandale, are ancient buildings, now in ruins.

Rental.

Farms.

Farms vary much in size—arable, from 50 to 600 acres, and hill sheep walks, from 300 to 3000. The latter description of land maintains about two sheep for every three acres. The number of farmers has been stated at 1300. The leases of arable land are from nineteen to twenty-one years, of sheep farms commonly from nine to thirteen years. The rents are all paid in money. The agriculture of this county seems to hold a middle place between that of the

Dumfries.

border counties of Roxburgh and Berwick and the Lothians, and the more northerly divisions of Scotland.

Agriculture.

Though the prevailing soil be light and friable, turnips do not generally form one of the crops in rotation, nor is it the practice of most farmers, who raise them on a smaller scale, to feed them off with sheep. The crop chiefly trusted to for keeping the land clean is potatoes, which are cultivated to a considerable extent, and receive nearly all the farm-yard manure. Wheat is not a general crop, and beans very rare. The growth of barley has been checked by the duties on malt. Oats are cultivated extensively on every farm. About 1,200,000 Winchester bushels of lime are supposed to be used every year as manure, the expence being about L. 54,000. The implements are not different from those in use in most parts of Scotland, except that single horse carts are almost universal. The fences on the sheep farms are dry stone walls, and on the low grounds white-thorn hedges; but the latter, owing to neglect, are often worse than useless. Mr Menteath of Closeburn laid down a large tract of thin peat moss with Yorkshire fog (*Holcus lanatus*), after paring and burning, and has found it to form a valuable pasture. He allows six bushels of seed, and a dressing of eighty bushels of lime to the Scots acre. Timothy has been cultivated with great success by Mr Mundell of the Academy at Closeburn. The cattle are of the Galloway breed, though not always unmixed; few comparatively are carried forward to the butcher, most of them being driven to the south, at the proper age for fattening. A number of Highland cattle, bought at the Falkirk Trysts, are kept for a season, and then resold, and also Irish cattle in a smaller proportion. The dairy is not an object of much attention. The number of cattle of all ages bred in the county has been computed to be 30,000. The sheep are of the Cheviot and black-faced breeds, with a few flocks of Leicester on the arable farms, the number of the whole being about 200,000. A great many hogs are bred and fattened chiefly on potatoes; the pork is cured in the county, and sent off in bacon for the London and Newcastle markets, to the yearly value, it is said, of about L. 50,000. The district of Annandale has the greatest share of this trade. For agricultural produce, the Winchester bushel and avoirdupois weight are in general use; but oatmeal, as in other parts of Scotland, is sold by the stone of $17\frac{1}{2}$ lb. avoirdupois, eight of which = 140 lb. make a boll.

Manufactures.

The manufactures of Dumfries-shire are not very extensive. Cottton-spinning at Langholm and Annan, and cotton-weaving at the latter place; linen only for home consumption; a small iron-work at Kirkconnel; a paper-mill, two small founderies, and several breweries and tanworks at Dumfries, and a carpet manufactory near Sanquhar, comprise all the branches worthy of notice. Salt was formerly made from sleech without paying duty, in the parishes of Cummertrees and Ruthwell, in consequence of an act in 1671, but the right to this exemption has been lately questioned.

Commerce.

The port of Dumfries extends from Southwick in the parish of Colvend, in the stewartry of Kirkcudbright, along the Solway Frith to the border stream of Sark, and therefore nearly all the exports and imports of the county by sea pass through it. In 1809, the entries inwards were 493 vessels, carrying 1339 men, and 18,985 tons; and 287 vessels cleared outwards, with 802 men, and 12,090 tons. Most of the inward vessels are laden with coal, and of the outward with grain. But its most valuable exports are cattle, sheep, bacon, and wool; almost all of which, excepting the last, are sent out of it by land.

Fisheries.

The only fisheries that can be said to belong to this county, which has no other communication with the sea than by the Solway Frith, are those of its rivers, and they are inconsiderable. The salmon fishings have lately failed, owing, it is alleged, to the fish being intercepted in their passage up the Solway, by the numerous stake-nets placed there in the salt water. The fishing ground to the west of the Annan, including a part of that river, was let some years ago for L. 900. An act was obtained for the protection of these fisheries in 1804.

Condition of the lower Classes.

It is not so common in this as in the other southern counties of Scotland, to have cottages on every farm; unmarried labourers, who live in the farmers' houses, being in many cases preferred. Hence the lower classes are lodged for the most part in towns and villages, where their accommodations are various as their means, but in general much superior to those which the country cottages afford. Many of these last are built of dry stone dashed with lime, some of them of stone and turf without any lime, and a few with walls of mud. In 1812, wages were from 1s. 6d. a day in winter to 3s. in harvest, and might average nearly 2s. 6d. throughout the year; but here, as in every other part of Scotland, country labour has fallen at least one-third within these few years, except that of married servants hired for the year, whose wages are paid in oatmeal and other kinds of farm produce. Their food, when they eat in their employers' house, is oatmeal and potatoes for breakfast and supper, with broth and meat to dinner. Peat or turf is the common fuel. They are all taught to read, and the boys at least to write and cast accounts; in many of the country parishes Latin, and in all the larger villages Greek and French may be learned for very moderate fees. The number of paupers is about one thousand, and the payments in common years do not exceed L. 3000. There is a poor-rate levied in a few parishes, which may amount to about one *per* cent. on the rent; and it is paid in equal proportions by the landlord and tenant.

Representation.

Dumfries-shire sends one member to Parliament; and the boroughs of Dumfries, Annan, Lochmaben, and Sanquhar, in this county, with Kirkcudbright in the stewartry of that name, join in electing a representative for the Scots boroughs. Moffat and Langholm are well built, populous, and thriving villages: several new ones have been laid out according to regular plans within these few years, by spirited proprietors. Graitney, or, as our southern neighbours write it, *Gretna Green*, has long been notorious for the celebration of clandestine marriages, for which it is conveniently situated near the English border. The local militia and yeomanry cavalry, in 1812, amounted to 1958, which, with the county militia,

Dumfries ‖ Dunbarton. Population.

made the whole of its military force about 2300. The population in 1800 and 1811 is given in the following abstract. See Singer's *General View of the Agriculture, &c. of the County of Dumfries*, 1812, and Sir John Sinclair's *General Report of Scotland*, 1814; with the articles DUMFRIES, county and borough, in the body of the work. See also for an account of its mineralogy, Professor Jameson's *Survey* in 1805: and *Caledonia* by Mr Chalmers, for its most interesting antiquities.

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
10,785	11,850	246	25,407	29,190	10,691	6317	37,146	54,597

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
11,660	12,964	299	29,347	33,613	3862	4435	4667	62,960

A.

Situation.

DUNBARTON, or DUMBARTON, a county in Scotland, situated between 55° 53′ and 56° 25′ N. Latitude, and between 3° 55′ and 4° 53′ W. Longitude from Greenwich, consists of two districts, six miles distant from each other. The western, which is much the larger, is about 40 miles long and 12 broad, and is bounded by Perthshire on the north; by Argyleshire, from which it is separated by an arm of the sea called Loch Long, on the west; by the river Clyde and Lanarkshire on the south-west and south; and by Stirlingshire on the east. The eastern district is completely enclosed by Stirlingshire and Lanarkshire. The whole county contains 230 square miles, or 147,200 English acres, of which the smaller division may comprise 25 miles or 16,000 acres. It is divided into 12 parishes, of which there are only two in the eastern district, Kirkintilloch and Cumbernauld. This last belonged to Stirlingshire, till the Earl of Wigton, whose property it was, became heritable sheriff of Dunbartonshire, when he procured it to be annexed to this county.

Extent.

Climate.

The prevailing winds are from the west and south-west, but easterly winds are frequent in the spring months. Showers are very common, but heavy and continued rains of rare occurrence. Frosts are seldom severe, and, except on the mountains, snow never lies long. The climate is, upon the whole, more favourable to pasturage and the growth of timber, than to tillage crops, but not insalubrious. The range of the barometer is about 2.80, and of the thermometer from 6° to 80°. The soils of the lower grounds are schistose clay, mixed with small stones; rich black loam on the banks of the Clyde; and gravel on the river Leven; but about two-thirds of the county consist of lofty mountains, some of them 3000 feet high, part of the ridge which crosses the island from Forfarshire to the Firth of Clyde, known in the districts to the eastward by the names of the Sidlaw, Ochill, and Campsie Hills.

Minerals and Fossils.

Coal, iron-ore, limestone, freestone, and slate, are its most valuable fossil productions. The only coal now worked is at Langfauld, in the parish of East Kilpatrick, on the southeast border, where the quantity raised annually is about 11,000 tons. About 3000 tons of ironstone are sent yearly to the Carron foundery from the parishes of Kirkintilloch and Cumbernauld. Limestone abounds in various parts, but, partly from its inferior quality, and partly from the want of coal to calcine it, it is not worked to a great extent, except at Langfauld, where the coal is quarried along with it, and at Netherwood and Cumbernauld. White and red freestone are met with in several places; the finest quarry is at Garscube, on the banks of the Forth and Clyde Canal. The only slate quarry that has been worked with success is at Camstradan, in the parish of Luss. The principal market for the slates is Glasgow, to which they are conveyed in lighters by the Leven and the Clyde.

Waters.

The only river of any note which can be said to belong to this county is the Leven, the outlet of Lochlomond, which, flowing for about five miles through a fine valley, joins the Clyde at Dunbarton Castle. Its waters, which are singularly pure and soft, are well adapted to the business of bleaching and printing cottons, branches which are established to a great extent along its course. The other

Dunbarton. streams are Luss, Froon, Finlays, Douglas, Falloch, and Luggie. Clyde, Endrick, and Kelvin, flow along its borders. Lochlong and Gareloch are arms of the sea; the first of which separates this county from Argyleshire; and the other penetrating the land for about seven miles, nearly detaches the peninsula of Roseneath from the mainland. While this extent of sea-coast affords the benefit of water carriage to so large a portion of the county, the inland tracts are benefited in almost an equal degree by the Forth and Clyde Canal, which passes through it for more than sixteen miles. The only remarkable lake is Lochlomond, which is about twenty-four miles long, and in its greatest breadth, towards the south, above six. About two-thirds of the shore, and most of its islands, thirty in all, are in Dunbartonshire; the rest belong to Stirlingshire. It is probably not to be equalled by any lake in Britain for the variety and magnificence of its scenery; the picturesque beauty of its wooded banks and islands, affording a striking contrast to the rugged and lofty mountains that rise in its vicinity. It covers about 20,000 acres, and its surface is supposed to be increasing. The best view of the lake is from a promontory above Luss, a village on the western shore.

Lochlomond.

Estates.

The landed property of this county is divided among about 150 individuals, exclusive of the feuars in towns. None of the estates are of great yearly value, and two-thirds of them are small. The valued rent is L. 35,382, 7s. 8d. Scots, of which near a third is held under entail; and, in 1811, the actual rent of the lands was L. 56,972, 15s. and of the houses L. 5791, 15s. Sterling. There are a number of seats belonging to the larger proprietors, among which Roseneath, the splendid mansion of the Duke of Argyle, is by far the most magnificent; and a great many villas, the property of manufacturers. The county sends one member to Parliament, and the town of Dunbarton joins with Glasgow, Rutherglen, and Renfrew, in electing one for the Scottish boroughs.

Rental.

Representation.

Farms.

The arable land of Dunbartonshire is divided into small farms, averaging not more than fifty acres; in the highland district it is common for artisans and others to hold pendicles, as they are called, below L. 12 of rent; and still lower in the scale are the cottagers, possessing from two roods to an acre, with grazing for a cow, at a rent of L. 5. The hill pastures are necessarily let out in farms of several hundred acres. Since the introduction of sheep, farms of this description, that formerly let at L. 20 and L. 30, have risen to L. 300 and L. 400. There are still instances of farms let to three or four tenants jointly. In addition to money rents, kain-fowls, and lambs are sometimes paid, and even the barbarous practice of exacting labour from the tenant and his horses is not altogether unknown. Hence agriculture, throughout the greater part of the county, is in a very backward state, and does not produce grain enough for the wants of the inhabitants. Two or more crops of corn are taken in succession. Potatoes come in place of fallow as a preparation for wheat, even on very unsuitable soils. Flax was cultivated till within these few years, to a small extent upon almost every farm, but the quantity is now nearly confined to what may give employment to the farmers' families in winter, very little being sown for sale. Oats and potatoes are the principal crops. The land, upon the whole, is well enclosed, partly with stone walls, and partly with hedge and ditch. All that is let out to farmers is held on lease, commonly for nineteen years. Few cattle are bred in the county, and not many fattened. It is the practice to buy Highland cattle, keep them for a season, and then resell them to go farther south. The dairy is now a source of profit on most farms. The cows are generally of the Ayrshire breed. Sheep are confined to the mountains, and are almost all of the black-faced breed. Much improvement in farm-buildings has taken place within these forty years; but so long as farms are so small, the accommodations must be of a very inferior description, to those met with in well cultivated districts. Cottages are, with few exceptions, very wretched. Some that have been lately built are covered with paper. The paper is repeatedly dipt in tar, and, when dry, nailed on like slates; a layer of pitch is then spread over it, and fine sand or smithy-ashes sifted above all. The roof is formed so flat as to incline to the horizon at an angle of only 10^0 or 12^0. This is not only a cheap but a durable covering, and serves for other buildings than cottages. Sheathing paper, such as is used for the bottoms of merchant ships, is most commonly employed, though some give the preference to brown packing-paper. It must be composed of hemp or linen rags, as that which is made of cotton does not imbibe a sufficient quantity of tar.

Agriculture.

Coppice Woods.

The woods and plantations of this county are extensive and valuable. According to the agricultural survey in 1810, their extent appears to be near 7000 English acres, of which about the half is coppice; yielding to the proprietors an yearly income almost equal to the rent of the arable lands. On spots unfavourable to oak, these coppice woods consist of ash, yew, holly, mountain-ash, birch, hazle, aspen, alder, crab, thorn, and willow. The age at which they are cut is from twenty-two to twenty-four years, when they are worth about L. 30 an acre; but there are instances of woods, of considerable extent, selling at much more, where proper attention has been paid to enclosing them, and afterwards thickening them by means of layers, or thinning them, as may be necessary. It is the usual practice to reserve a certain number of young trees at each cutting, the greater part of which are cut down at the second fall, when they are nearly fifty years old, and the rest left to grow up to timber trees. The soil and climate of this county are particularly favourable to plantations, which begin to make a return to their owner in ten or twelve years, and in thirty years afford supplies to the carpenter. The most extensive plantations are on the estate of Luss. There is a very fine ash in Bonhill church-yard, the branches of which cover an area 100 feet in diameter. Its trunk is about nine feet high, of which the smallest diameter is six feet, and its three principal branches are from ten to twelve feet in circumference. On

Dunbarton.

the banks and islands of Lochlomond there is a considerable number of yew trees, some of them of great size.

Manufactures.

The manufactures of this county are various and extensive. Of these the printing of cottons is entitled to the first place. Next to this is the bleaching of cotton, carried on at nine fields, which forms a part of the business of the calico-printers. There are also three extensive cotton-mills, three paper-mills, an iron-work at Dulnotter for edge-tools and all sorts of wrought iron goods, large glass-works and several tan-works at Dunbarton; a manufacture of alkali at Burnfoot of Dalmuir, and a distillery of pyroligneous acid at Milburn. On the short course of the river Leven, not much exceeding three miles in a direct line, there are six large printfields and five bleachfields; and the rivulet of Duntocher or Dalmuir, in a still shorter course, turns no fewer than sixteen water-wheels. The extent of the whole, n 1810, is thus stated:

Ground occupied, about (Scots acres)	350
Value of buildings and machinery,	L. 250,000
Coals consumed annually, tons -	32,000
Yearly expence in fuel, -	L. 19,000
Number of hands employed of both sexes, and all ages, - -	3000
Average earnings about 2s. a-day.	
Total yearly wages, allowing for interruptions from sickness and other causes, - -	L. 90,000
Excise duties annually, -	L. 140,000

Besides these large establishments there is a number of lint-mills, two woollen-mills, chiefly employed in carding, and several fulling-mills.

Fisheries.

The gross produce of the salmon-fisheries of this county may be about L. 1000 a-year; the principal one is upon the river Leven. Those on the Clyde and Lochlomond are comparatively of little importance. About fifty boats are employed in the herring fishery, of which the annual value may be about L. 4500.

Condition of the People.

The wages of labour are higher in this than in most of the Scottish counties. In 1810, farm servants, who are for the most part unmarried, had from L. 35 to L. 42 a-year, and when manufactures are prosperous, many of the workmen in them earn nearly twice as much. Provisions are also dear; and fuel, which is principally coal, the greater part of it brought from the adjoining counties, is in many parts higher priced than in our largest cities. There were about 274 paupers in the county in 1811, but few of them were maintained solely on parochial charity. Such as are able to gain their subsistence in part by their own industry, receive only what is necessary to support them in addition to their own earnings; and those who are altogether incapable of work, are in most cases relieved by the charity of individuals, the parish paying only for clothes and house rent. The whole sum expended by the parishes does not much exceed L. 1000 a-year, of which only L. 290 is raised by assessment. The rent of land and interest of capital amount to L. 200, incidental funds to L. 120, and the collections at the churches to L. 390.

Poor.

Population.

The population of Dunbartonshire, in 1756, was 13,253; in 1790-8, 17,743. The population in 1800 and 1811 is given in the following tables. About a third of the inhabitants live in Dunbarton and six other smaller towns. See *Statistical Account of Scotland*.—*Beauties of Scotland*, Vol. III.; and Whyte and Macfarlan's *General View of the Agriculture of the County of Dunbarton*, 1811.

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
3375	4418	107	9796	10,914	4633	7952	8131	20,710

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
3218	4934	90	11,369	12,820	1123	2689	1122	24,189

(A.)

Dundas.

DUNDAS (Henry, Viscount Melville), a late eminent British statesman, was born about the year 1741. He was a younger son of the Right Honourable Robert Dundas, Lord President of the Court of Session in Scotland, by Miss Gordon, a daughter of Sir William Gordon of Gordonston, Bart. He was educated at the High School and University of Edinburgh, and having been brought up to the profession of the law, was admitted a member of the Faculty of Advocates in the year 1763. He soon distinguished himself at the bar, and rapidly attained to extensive practice. The first promotion he obtained was the situation of one of the Assessors to the Magistrates of Edinburgh; after which he became, successively, an Advocate-depute, and Solicitor General. In 1775, when Sir James Montgomery was appointed Lord Chief Baron, Mr Dundas succeeded him in the office of Lord Advocate, which situation he continued to occupy until 1783. In the month of March 1777, he was appointed joint Keeper of the Signet for Scotland.

From the period of his appointment to the office of Lord Advocate, Mr Dundas in a great measure abandoned the ordinary practice of the bar, and devoted himself to public business. In 1774, he became a Member of Parliament, having been elected representative for the county of Edinburgh. Some years afterwards, he resigned the representation of the county in favour of the present Lord Chief Baron, and was chosen Member for the city of Edinburgh, which he continued to represent, until his advancement to the peerage. Although originally returned to Parliament in opposition to the ministerial interest, he soon joined the party in power, and became a strenuous supporter of Lord North's measures during the American war. He frequently spoke in the House of Commons, and notwithstanding the disadvantages of an ungraceful manner, and a provincial dialect, he was always listened to with great attention, on account of the clearness of his statements, and the weight of his arguments.

In the year 1782, Mr Dundas was admitted a member of the Privy Council, and appointed Treasurer of the Navy, under the administration of the late Marquis of Lansdowne, then Earl of Shelburne; and he continued to fill that office, and to support the measures of government, until the dissolution of that ministry. During the short coalition administration he was out of place, and made a conspicuous figure in opposing the memorable East India Bill, a measure which occasioned the overthrow of the ruling party. Upon that occasion, he displayed a knowledge of the affairs of the East India Company, which was evidently the result of much study and laborious investigation. In the month of December 1783, when Mr Pitt became Prime Minister, Mr Dundas was restored to the same office he had previously held; and was appointed President of the Board of Control, under the new East India System. In 1791, he became a member of the Cabinet, in consequence of his appointment to the office of Principal Secretary of State for the Home Department. The duties of this office he discharged with energy and ability. The volunteer system, which, undoubtedly, contributed much to rouse the spirit of the country, during a period of peculiar difficulty and danger, has been ascribed to Mr Dundas. On the accession of the Duke of Portland to the administration of Mr Pitt, he resigned the Home Department, and became Secretary at War. At this time, he also held the offices of Lord Privy Seal, and Governor of the Bank of Scotland; and enjoyed an extent of patronage in his native country, which has seldom, if ever, fallen to the share of any individual, and has been considered by many as more exclusive than can be safely confided to the hands of any one man. For many years, he was the intimate friend and coadjutor of Mr Pitt, and took a leading part in all the important measures of his administration. The details of these measures, and Lord Melville's conduct in regard to them, belong to history. In the present article we must restrict ourselves to a general outline of the events of his life, and a short summary of the leading traits of his character.

Upon the resignation of Mr Pitt, in 1801, Mr Dundas also resigned his political offices; and, in 1802, under the administration of Mr Addington (now Lord Sidmouth), he was elevated to the peerage, by the titles of Viscount Melville and Baron Dunira. The last public situation which he held in the government was that of First Lord of the Admiralty, to which he was appointed, on Mr Pitt's return to power, in the room of Lord St Vincent. It was in his administration of the affairs of the navy department, that his Lordship incurred that irregularity, relative to the balances of public money remaining in his hands, which produced his celebrated impeachment. We conceive it unnecessary to dwell upon the proceedings of that well-known trial. It is sufficient to say, that the House of Lords finally acquitted him of all the charges brought forward in the articles of impeachment exhibited by the Commons; but he had previously resigned all his offices in the administration.

Subsequently to his acquittal, Lord Melville was restored to his seat in the Privy Council; but did not return to office. He sometimes took a share in the debates in the House of Lords; and, in 1810, he brought forward a motion, the object of which was to recommend the employment of armed troop-ships, instead of hired transports, for the accommodation of such troops as it might be found expedient to embark in furtherance of the public service. But the greater part of his time was spent in Scotland, where he died suddenly, at the house of his nephew, the Right Honourable Robert Dundas, Lord Chief Baron of the Exchequer, on the 27th of May 1811, at the age of seventy-one. He appeared in his usual state of health for some time preceding, and his death is supposed to have been hastened by the affliction he felt for the loss of his old and valued friend, the Lord President Blair, who died a few days before.

In his person, Lord Melville was tall, stout, and well formed. In public life, he was principally distinguished by his great capacity for business, by the unwearied attention which he paid to the details of all official measures, and by the manliness and deci-

sion of his conduct. For many years, as we have already observed, he was the steady friend and firm supporter of the measures of Mr Pitt, to whom he proved a very powerful auxiliary. While he held the offices of Treasurer of the Navy, and First Lord of the Admiralty, his exertions are admitted to have been attended with great advantage to the public service. He devised several improvements in the details of that department, which have been found of great utility; and, in particular, the regulations with regard to the payment of seamen's wages, transmission of letters, and other matters connected with that branch of the public service, contributed much to the comfort of that class of men, and are highly honourable to the character of their author. In Parliament, he was a clear, acute, and argumentative speaker. His eloquence, however, was that of a man possessed of strong natural talents, wholly unadorned by literary taste or acquirements; and his speeches produced their effect from the solidity of his arguments, and the fearlessness with which he delivered his opinions, not from any powers of oratory, or graces of style. The ornamental parts of eloquence, indeed, he seemed to despise, and was satisfied to bring his audience at once to the object he had in view. Political power was his passion; and the bustle of official life was the element in which he loved to move.

In private life, his Lordship was a most agreeable companion; easy, frank, and convivial; careless of of money, even to a fault; always disposed to do kind offices; affectionate in his domestic relations, and greatly beloved by the numerous circle of his friends.

Lord Melville was twice married: first, to Miss Rannie, daughter of Captain Rannie of Melville, by whom he had one son, Robert, now Lord Melville; and three daughters. His second wife was Lady Jean Hope, sister to the late Earl of Hopetoun, by whom he left no issue.

Although not, strictly speaking, a literary man, Lord Melville is the author of several pamphlets, on political subjects, which are distinguished by his usual sense and knowledge of business. These are,

The Substance of a Speech in the House of Commons, on the British Government and Trade in the East Indies, April 23, 1793. London, 1813. 8vo.

Letter to the Chairman of the Court of Directors of the East India Company, upon an Open Trade to India. London, 1813. 8vo.

Letters to the Right Honourable Spencer Percival, relative to the Establishment of a Naval Arsenal at Northfleet. London, 1810. 4to. (H.)

DUNNING, John (Lord Ashburton), a celebrated English counsellor, was the second son of Mr John Dunning of Ashburton, Devonshire, an Attorney. He was born at Ashburton, on the 18th of October 1731; and was educated at the free grammar school of his native place, where he soon distinguished himself by his proficiency in classical literature, as well as the mathematics. On leaving school, he was taken into his father's office, where he remained until the age of nineteen, when he was sent to the Temple. After he came to the bar, he got very slowly into practice. In the year 1762, he was empolyed to draw up *A Defence of the United Company of Merchants of England trading to the East Indies, and their Servants (particularly those at Bengal), against the Complaints of the Dutch East India Company to his Majesty on that Subject;* which was considered a masterpiece of language and reasoning; and from which he derived not only immediate profit, but such a large share of reputation as secured him extensive practice in his profession.

In 1763, he distinguished himself, as counsel, in the memorable proceedings in the case of Wilkes; and his professional business, from that period, gradually increased to such an extent, that, in 1776, he is said to have been in the receipt of nearly L. 10,000 *per annum.* In 1766, he was chosen Recorder of Bristol; and on the 23d of December 1767, he was appointed to the office of Solicitor-General, which he held until the month of May 1770, when he retired, along with his friend Lord Shelburne. In 1771, he was presented with the freedom of the city of London. From this period, he was considered as a regular member of the opposition party, and distinguished himself by many able speeches in Parliament. He was first chosen member for Calne in 1768, and continued to represent that borough until he was promoted to the peerage. In 1782, when the Marquis of Rockingham became prime minister, Mr Dunning was appointed Chancellor of the Duchy of Lancaster; and about the same time he was advanced to the peerage, by the title of Lord Ashburton of Ashburton. He died while on a visit to Exmouth, on the 18th of August 1783.

The person of Lord Ashburton was by no means agreeable or prepossessing. He was a short thick man, with a sallow countenance, a constant shake of the head, and a hectic cough, which frequently interrupted the stream of his eloquence. His oratory, however, was at once fluent, elegant, and argumentative; and he possessed a sound knowledge of the laws, and of the theory of our constitution. His language was pure and classical, yet peculiar to himself; and he had a great fund of wit and humour. His disposition was originally timid, but this defect he overcame by practice, as he became more familiar with forensic habits. Of the great extent of his practice some notion may be formed from the fortune he left behind him, which was all earned by his own exertions, and amounted to no less a sum than L. 180,000.

Sir William Jones has pronounced a splendid eulogium on the character of Lord Ashburton. "His language," says that accomplished scholar, "was always pure, always elegant; and the best words dropped easily from his lips into the best places, with a fluency at all times astonishing, and, when he had perfect health, really melodious. His style of speaking consisted of all the turns, oppositions, and figures, which the old rhetoricians taught, and which Cicero frequently practised, but which the austere and solemn spirit of Demosthenes refused to adopt from his first master, and seldom admitted into his ora-

tions, political or forensic. That faculty, however, in which no mortal ever surpassed him, and which all found irresistible, was his wit. This relieved the weary, calmed the resentful, and animated the drowsy; this drew smiles even from such as were the objects of it; scattered flowers over a desert; and, like sun-beams sparkling on a lake, gave spirit and vivacity to the dullest and least interesting cause. He was endued with an intellect, sedate, yet penetrating; clear, yet profound; subtle, yet strong. His knowledge, too, was equal to his imagination, and his memory to his knowledge."

Besides the *Answer to the Dutch Memorial*, Lord Ashburton is supposed to have assisted in writing a pamphlet on the law of libel, and to have been the author of *A Letter to the Proprietors of East India Stock, on the subject of Lord Clive's Jaghire, occasioned by his Lordship's Letter on that Subject*; 1764, 8vo. His Lordship was at one time suspected of being the author of the celebrated *Letters of Junius*. See Chalmers's *Biog. Dict.*, and Sir W. Jones's *Works*, Vol. IV. (H.)

DUPUIS (Charles Francis), an eminent French writer, and member of the Institute, was born of poor parents at Trýé-Chateau, between Gisors and Chaumont, on the 26th of October 1742. His father, who was a teacher, instructed him in mathematics and land-surveying. The Duke de la Rochefoucault, who accidentally became acquainted with the youth, took him under his protection, and gave him a bursary, or exhibition, in the college of Harcourt.

Dupuis made such rapid progress in his studies, that, at the age of twenty-four, he was appointed Professor of Rhetoric at the College of Lisieux. In his hours of leisure, he applied himself to the study of the law, and on the 11th of August 1770, he was admitted an Advocate before the Parliament. He was charged by the Rector of the University with the task of delivering the customary discourse at the distribution of prizes; and he was also employed, in the name of the University, to compose the funeral oration of the Empress Maria Theresa of Austria. These two works having been printed, were admired on account of their elegant latinity, and laid the foundation of the author's fame as a writer.

The mathematics having been the object of his early studies, he now devoted his more serious attention to that science; and for some years he attended the astronomical lectures of Lalande, with whom he formed an intimate friendship. In 1778, he constructed a telegraph on the principle suggested by Amontons; and he succeeded so well, that he was enabled to correspond with his friend M. Fortin, who, from the village of Bagneux, where he had a country seat, observed with a telescope the signals made by Dupuis at Belleville, and returned his answer on the following day. In this manner they continued to correspond every year, during the fine season, from 1778 to the commencement of the Revolution. Dupuis then destroyed his machine, lest it should render him suspected in those dangerous times.

Much about the same time, Dupuis formed his ingenious theory with respect to the origin of the Greek months. In the course of his investigations upon this subject, he composed a long memoir on the constellations. He had been struck with the singularity of the figures, by which the groups of stars, called constellations, were represented on the most ancient planispheres; and had also remarked, that these groups did not present to the eye any form analogous to their representations. Hence he concluded, that the real configurations of these constellations, or asterisms, could not have been the origin of the figures, and of the names which had been given to them from the highest antiquity. Dupuis attempted to resolve this enigma, in so far, at least, as related to the constellations of the zodiac. He conceived that this representation of the heavens, during the course of the year, must have some reference to the state of the earth, and to the labours of agriculture, at the time, and in the country, in which these signs had been invented; so that the zodiac was, for the people who invented it, a sort of kalender at once astronomical and rural. It seemed only necessary, therefore, to discover the clime and the period, in which the constellation of *Capricorn* must have risen with the sun on the day of the summer solstice, and the vernal equinox must have occurred under *Libra*. It appeared to Dupuis, that this clime was Egypt, and that the perfect correspondence between the signs and their significations had existed in that country for a period of between fifteen and sixteen thousand years before the present time; that it had existed only there; and that this harmony had been disturbed by the effect of the precession of the equinoxes. He therefore ascribed the invention of the signs of the zodiac to the people who then inhabited Upper Egypt, or Ethiopia. This was the basis on which Dupuis established his mythological system, and endeavoured to explain the curious subject of fabulous history, and the whole system of the theogony and theology of the ancients.

Persuaded of the importance of his discoveries, which, however, were by no means entirely original, Dupuis published several detached parts of his system in the *Journal des Savants*, for the months of June, October, and December 1777, and of February 1781; which he afterwards collected and published, first in Lalande's *Astronomy*, and then in a separate volume in 4to, 1781, under the title of *Memoire sur l'Origine des Constellations, et sur l'Explication de la Fable par l'Astronomie.* The theory propounded in this memoir was refuted by M. Bailly, in the 5th volume of his *History of Astronomy*; but, at the same time, with a just acknowledgment of the erudition and ingenuity exhibited by the author.

Condorcet proposed Dupuis to Frederick the Great of Prussia, as a fit person to succeed Thiebault in the Professorship of Literature at Berlin; and Dupuis had accepted the invitation, when the death of the king put an end to this engagement. The chair of Humanity, in the College of France, having, at the same time, become vacant by the death of M. Bejot, it was conferred on Dupuis; and, in 1788, he became a member of the Academy of Inscriptions. He now resigned his professorship at

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Lisieux; and was appointed, by the administrators of the department of Paris, one of the four commissioners of public instruction.

At the commencement of the revolutionary troubles, Dupuis sought an asylum at Evreux; and having been chosen a member of the National Convention by the Department of the Seine and Oise, he distinguished himself by the moderation of his speeches and public conduct. In the third year of the republic, he was elected secretary to the Assembly; and, in the fourth, he was chosen a member of the Council of Five Hundred. After the memorable 18th of *Brumaire*, he was elected, by the Department of the Seine and Oise, a member of the Legislative Body, of which he became the president. He was afterwards proposed as a candidate for the Senate; and here terminated his political career.

In 1794, he published his large work, entitled, *Origine de tous les Cultes, ou la Religion Universelle*, 3 vols. 4to, with an atlas; or 12 vols. 12mo. This work excited considerable sensation at first; it gave umbrage to many; was attacked and defended with warmth; at length, ceased to be read, and fell into utter neglect. In 1798, he published an abridgment of this work in one volume 8vo, which met with no better success. Another abridgment of the same work, executed upon a much more methodical plan, was published by M. de Tracy. The other works of Dupuis consist of two memoirs on the *Pelasgi*, inserted in the *Memoirs of the Institute;* a memoir *On the Zodiac of Tentyra*, published in the *Revue Philosophique*, for the month of May 1806; and a *Memoire Explicatif du Zodiaque Chronologique et Mythologique*, published the same year, in one volume 4to. It was from the perusal of the poem of *Nonnus*, which he once thought of translating into French, and of which a fragment was printed in the *Nouvel Almanach des Muses*, for the year 1805, that Dupuis caught the first idea of his astronomical system.

Dupuis died at Is-sur-Til, on the 29th of September 1809, leaving behind him several manuscripts on subjects connected with the works he had published during his life. He was a member of the Legion of Honour; and his character was that of an honest man, and a paradoxical writer. He was born poor, and never acquired any fortune. M. Dacier, secretary to the Third Class of the Institute, delivered his *Eloge;* and an historical account of his life and writings was published by his widow. See also *Biog. Universelle*. (H.)

DURHAM, a county palatine in the north of England. The ancient names, boundaries, form, extent, rivers, and the civil and ecclesiastical divisions of Durham, have been largely and correctly described in the *Encyclopædia*, to which we refer the reader.

This is the only county palatine remaining in England; and it is called *palatine*, from *a palatio*, because the owners thereof had, in this county, the authority to use the royal prerogative, as fully as the king had in his palace. The palatine privileges were granted to this county, probably on account of its bordering upon the inimical kingdom of Scotland, in order that the inhabitants, having justice administered at home, might not be obliged to go out of their county, and leave it open to an enemy's incursions; and that the owners, being encouraged by so large an authority, might be the more watchful in its defence. There is a Court of Chancery in this county; and the bishop is at the head of the administration of justice.

Durham.

Surface. The western angle of the county of Durham is hilly and mountainous, with black, naked, and barren regions, crossed by a ridge of high hills, from whose sides issue numerous streams flowing to the sea. There are some beautiful and fertile vallies in the eastern and central parts, pleasantly varied with hill and dale, and alternately appropriated to corn and pasture. The waste lands occupy nearly 120,000 acres of the western part of the county; in the southern districts, many hundred acres have been enclosed and cultivated within the last forty years. The common fields are now but few; for the land belonging to the townships has been enclosed above a century. There is a great portion of wet ground still remaining, although draining is carried on to a great extent.

Soils. Near the river Tees, and in some spots bordering the other rivers, the soil is loam or a rich clay. At a further distance from these rivers, the soil is of an inferior quality, marshy, with patches of gravel interspersed. The hills between the sea, and an imaginary line drawn from Barnard Castle on the Tees, to Alansford on the Derwent, are covered with a dry loam, the fertility of which varies with its depth. From this line westward, the summits, as well as the sides of the hills, are moorish wastes.

Woods and Roads. The woodlands of Durham are not of very considerable extent, trees being chiefly confined to the parks and seats of the nobility and gentry; but many plantations have been made of late years. The banks of the rivers and brooks, however, particularly in the vicinity of Durham, are fringed with wood of long growth, and much value. The public roads are in general good; but those belonging to private districts and townships want improving.

Ports. The port of Stockton-upon-Tees is well situated for commerce. Hartlepool, situated on a promontory, nearly encompassed by the German Ocean, which, on the south side of the town, forms a capacious bay, is advantageously placed for the reception of vessels, and landing of troops from the Continent. And South Shields sends out many ships.

Minerals. The mineralogical substances found in Durham are numerous and valuable. The coal mines are some of the most extensive and productive in the kingdom; and the quantity of this important article is so great as to exceed all calculation. At Sunderland the coal trade furnishes employment for 520 vessels, independent of the *keels* which convey the coal from the staiths to the ships, and are 492 in number. This coal is chiefly conveyed to the metropolis, though great quantities are sent to the different ports of the Baltic; and in time of peace to France and Holland. The whole quantity annually exported from Sunderland alone amounts to about 315,000 Newcastle chaldrons, each chaldron equal to 53 cwt. The number of persons dependent on this trade is very great; and some years ago, when the consumption was by no means so great as it is

Durham. at present, amounted to upwards of 26,000 on the river Wear only. The seams, or strata, now worked, are five in number, extending horizontally for many miles, and are from twenty to one hundred fathoms beneath the surface; each stratum is from three to eight feet thick. Below these are several other seams of coal; and many parts of the county, besides those where the pits are now open, abound with this substance.

Lead. The principal lead mines of Durham are situated in Tees Dale and Wear Dale; those of the former place have not been very productive, but the produce of the latter is of considerable value. The general method of working them is similar to that pursued in other mining counties. The ore of Wear Dale is melted by the blast-hearth, but in Tees Dale air-furnaces have been introduced with much success.

Iron. Ironstone is found in the neighbourhood of Swalwell and Winlaton, where are the first iron-works in England.

Quarries. Some excellent quarries of slate for buildings have been opened in different parts of the county. A beautiful black spotted limestone is dug up near Walsingham, and made into hearths, chimney-pieces, and other ornaments. This neighbourhood abounds also with fine mill-stones. The Newcastle grindstones are procured at Gateshead Fell; and firestone of high estimation for building ovens, furnaces, &c. is obtained in various parts of Durham, and exported in immense quantities.

Salt Works Several extensive works for manufacturing salt from sea-water have long been established in the neighbourhood of South Shields; but, owing to the discovery of a very singular salt spring at Birtley in this county, that process is not so much attended to now. This water rises at the depth of seventy fathoms, in an engine pit, constructed for drawing water out of coal mines. It has, for many years, produced 20,000 gallons *per* day, four times more strongly impregnated with salt than any sea-water. In consequence of the discovery of this spring, about twenty-five years ago, a large and extensive manufactory of salt has been established near the spot, the quality of which is excellent. At Butterby, near Durham, is another salt spring, which issues from a rock in the river Wear, and is visible when the water is low only; it contains more of the sulphat of magnesia, or Epsom salt, than the spring at Birtley.

Chalybeate Spring. Within a few yards of the Water-gate, on the south side of the town of Hartlepool, is a chalybeate spring, covered every tide by the sea. It is impregnated slightly with sulphur, which evaporates very quickly, leaving a sediment with salt of tartar; a gallon will yield 120 grains of sediment, two parts of which are nitrous, the rest limestone.

Agriculture. Improvements in agriculture have been pursued with considerable spirit and success, in the environs of Darlington, chiefly through the patronage of a society of respectable gentlemen, who hold their meetings in the town, and bestow premiums upon merit. The usual rotation of crops in this county is, after summer fallow, wheat, oats, beans, or peas. On some spots of gravelly soil, turnips and barley are grown in almost perpetual succession; a crop of clover being sometimes interposed. The produce of wheat, on good land, is from twenty to thirty bushels *per* acre; the produce of barley is from thirty to forty; of oats from twenty to forty. The manures are chiefly lime, and the produce of the fold-yard; and though abundance of sea-weed might be collected on the coast, the farmers make but little use of it. The farms are of a middling size, few of them exceeding 200 acres. The largest portion of each farm is appropriated to tillage; but towards the western extremity of the county the whole is applied to pasture. The leases seldom exceed six years, and are, too frequently, rendered of little value by injudicious restrictions. The leases held of the see of Durham are generally for lives, or for twenty-one years, renewable every seven years, on payment of a fine. The farm-houses are well situated and commodious; and improvements in farming, and farming machinery, become more and more common.

Cattle. The cattle of Durham are, at present, in great repute; as, for form, weight, produce of milk, and quickness of fattening, there are none better. The sheep also, particularly the Tees water breed, stand high in estimation. It is the largest breed in the island; the legs being longer, finer boned, and supporting a thicker and more firm and heavy carcase than the Lincolnshire. They are also much wider on the backs and sides, and afford a fatter and finer grained mutton. The weight *per* quarter, in two years' old wethers, is from 25 to 35 lbs.; and, in particular instances, 55 lbs. or more. The wool is shorter and lighter than some other English breeds. The Wear Dale sheep are small, but the meat finely flavoured. When fat the quarters seldom weigh more than fourteen or eighteen pounds each.

Manufactures. Durham, taking its dimensions into consideration, is inferior to no county in Great Britain for its numerous manufactures. It has cast-metal founderies, iron manufactories, potteries, glass-houses, copperas works, coal-tar, and salt-works, quarries of marble, &c.; besides linen and woollen manufactories.

Curiosities. At the distance of about three miles from Darlington, at Oxenhall, are cavities in the earth, denominated *Hell-kettles*, to the origin of which are attached many fabulous conjectures. The diameter of the largest is not less than 114 feet, and that of the least 75. About five miles from Hartlepool is one of the most singular and romantic clusters of rocks in the north of England, called *Black Halls*; formed by the force and constant action of the waves, which have separated enormous masses from the coast, washing some entirely away, but leaving others standing, like the vast towers of a cathedral: in some places the rock is perforated so as to resemble a fine pointed archway.

British Antiquities. Near the north wall of the church-yard at Ryton is a large barrow, about twenty feet in perpendicular height, now planted with trees. It does not appear to have been opened; but a similar one, near Bradley Hall, in the same parish, inspected about 35 years ago, was found to contain a square cavity, formed by stones placed edge-ways, in which a hu-

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man body was interred. Between one and two miles north of Brancepeth is Brandon Hill, a lofty eminence, on the summit of which is a remarkable tumulus, of an oblong form, 120 paces in circumference at the base, and about twenty-four feet in perpendicular height. It does not appear to have been opened. One mile north of Eggleston is an ancient structure, called the *Standing Stones*. This originally consisted of a cairn in the centre, surrounded by a trench, and that again encompassed by a circular arrangement of rough stones; many of which have been removed and broken, to repair the roads. Near a brook, at a small distance, is a large barrow, crossed from east to west by a row of stones.

Roman Remains.

On Fullwell Hill, a gigantic skeleton and two Roman coins were discovered about fifty-five years ago, together with a small urn of unbaked clay. Several copper coins have been found at the village of Whitburn. Some coins of the Emperor Adrian were found while widening the road near Gateshead, which is supposed to have been a Roman station.

South Shields was the *ad finam* of Richard of Cirencester's itinerary, as appears from the Roman altars, coins, and other relics found there. Evchester, a small irregular village, is supposed to be the *Vindomara* of Antoninus; many Roman inscriptions, and an urn of uncommon form, nearly a yard high and seven inches wide, and having in the centre a small cup, have been found there. Chester-le-Street has been supposed to be the *Condercum* of the Romans, situated on the military way leading to Newcastle. *Glanibanta,* near the village of Lanchester, is another Roman station, which has survived the ravages of cultivation in an extraordinary degree, and is one of the most perfect in the kingdom. It occupies a fine eminence, is of an oblong figure 174 paces from north to south, and 160 from east to west, within the vallum. In some parts, the wall still remains perfect; the outside is perpendicular, twelve feet in height, built of ashler work in regular courses, each stone being about nine inches thick, and twelve long. The site of the Pretorium is clearly distinguishable. Binchester, the seat and manor of the Wren family, is the site of the Roman station called *Vinovium* by Antoninus. Its figure and extent seem nearly similar to those of the station just mentioned; but the walls have been destroyed, and the area enclosed and cultivated. A military way, it is supposed, issued from it, leading towards Chester-le-Street. Innumerable fragments have been discovered here.

Castles.

The most ancient part of Durham Castle is the keep, now a mere shell; the magnificent hall is fast going to decay. Hilton Castle, an ancient baronial residence of the Hyltons, is situated in a pleasant vale on the north side of the Wear, about three miles from Wearmouth; its present form is that of an oblong square; the interior consists of five stories; the rooms are small, and exhibit every symptom of neglect and decay. Ravensworth Castle, the seat of Sir Thomas Henry, occupies part of the site of an ancient castle, which seems to have formed a quadrangle, having a square tower at each angle, connected by a curtain wall. Two of the towers are built up in the offices, the others are partly in ruins. Lumley Castle, about a mile to the east of Chester-le-Street, is one of the seats of the Earl of Scarborough. It forms a quadrangle, with an area in the centre; at each angle are projecting turrets of an octangular form; it is a grand model of the taste of its age. Brancepeth Castle, an irregular, but stately pile, was erected about Stephen's reign, by the family of Bulmers. The original building has had many modern improvements added to it by the present proprietor. The castle of Bishop Auckland stands on the north angle of the town, and together with its courts and offices, covers about five acres of ground. Raby Castle, the magnificent seat of the Earl of Darlington, owes its splendour to the Earl of Westmorland, who enlarged a more ancient castle which stood here prior to the year 1379. The present mansion of Streatham Castle was erected on the foundation of the old castle at the beginning of the last century, and several of the apartments are retained in it. Barnard Castle is situated on the southern acclivity of an eminence, rising with a steep ascent from the river Tees; its ruins cover an extensive plot of ground.

Abbeys.

Kepier Hospital, near Durham, was founded in 1112; but the only part of the monastic buildings now standing is the gateway, a strong and not unhandsome piece of masonry with pointed arches. The ruins of a monastery for Grey Friars may be seen at Hartlepool. Several remains of monastic buildings occur near the church at Monk Wearmouth. The monastery of Jarrow may still be traced in its ruins on the summit of an elevated ridge near the church. On the east side of the main street of Gateshead are the ruins of St Edmund's Monastery, which appears, from Bede, to have been established before the year 653. Finchall Priory was beautifully situated in a vale on the banks of the Wear; the ruins cover an extensive plot of ground, but are so much dilapidated, that the original appropriation of their respective parts can be traced only with great difficulty. The remains of a chapel at Bear Park are most perfect, and display some neat ornamental architecture. There is at Walsingham the ruins of a considerable building, enclosed with a deep moat, supposed, by some, to have been a part of a monastery.

Churches.

The ecclesiastical buildings now remaining, and most worthy notice, are the following:—The Cathedral of Durham, begun in 1093, in the Saxon and Norman style; Sedgefield Church, in the Saxon style; Bishop Wearmouth Church, supposed to have been founded very soon after the restitution made by Athelstan; and the parish church of Brancepeth, an ancient structure of the conventual form, but apparently of different ages.

Seats.

The county of Durham contains a great number of noblemen and gentlemen's seats. The following are some of the principal:—Streatham Castle, of the Earl of Strathmore; Shincliff-Hall, of R. Scott, Esq.; Croxdale-Hall, of W. Salvin, Esq.; Raby Castle, of the Earl of Darlington; Lumley Castle, of the Earl of Scarborough; Castle Eden, of R. Burdon, Esq.; Harwicke, of M. Russel, Esq.; Windleston, of Sir John Eden, Bart.; Grange-Hall, of G. Allan, Esq.; Winyard, of Sir H. V. Tempest,

Bart; Seaham, of Sir R. Milbanke, Bart.; Ravensworth Castle, of Sir S. H. Liddel, Bart.; Axwell Park, of Sir T. Clavering, Bart.; Gibside, of the Earl of Strathmore; Lambton Hall, of the Lambtons; and Bradley Hall, of the Bowes family.

Titles. The following titles are furnished by this county: Darlington, an Earldom to the family of Vane; Baron Auckland to that of Eden; and Viscount Lumley to the Earl of Scarborough.

Population. The returns of the population of Durham are as follows:—In 1700 the inhabitants were 95,500; in 1750, 135,000; in 1801, 165,700; in 1811, there were,

Inhabited houses, - -	29,033
Families inhabiting them, -	39,288
Houses building, - -	152
Uninhabited, - -	890
Families employed in agriculture,	10,288
In trade, manufactures, and handicraft, - - - - -	17,094
Not included in the above classes,	11,906
Total of males, -	83,671
——— females, -	93,945
Grand total, -	177,625
Population of 1801, -	165,700
Increase, - - - -	11,925

See Hutchinson's *Antiquities of Durham*; and *Beauties of England and Wales*, Vol. V. (Y.Y.)

DUSSAULX (JOHN), a French writer, best known as the translator of *Juvenal*, was born at Chartres, on the 28th of December 1728. He studied first at La Fleche, and afterwards at Paris. Having obtained the situation of a Commissary in the *gendarmerie*, he served under the Marshal de Richelieu, in Hanover, during the seven years' war. At the age of twenty-one, he was admitted a Member of the Academy of Nanci; and, in 1770, he published his translation of *Juvenal*. This work procured him admission into the Academy of Inscriptions: and he was also appointed Ordinary Secretary to the Duke of Orleans.

For some years he quietly prosecuted his literary occupations at Paris; but, upon the breaking out of the Revolution, his enthusiastic disposition led him to adopt its principles; and he took a part in the debates of the Legislative Assembly. He spoke and voted, however, at all times, for moderate measures; and, on several occasions, he was employed to calm the passions of the people during public tumults. At the memorable sitting of the Convention, of the 15th of January 1793, he voted that the King should be detained in custody during the war, and banished on the return of peace. It is rather remarkable, that, when the Committee of Public Safety wished to send him to the scaffold, his pardon was obtained by Marat; who represented him as an old dotard, incapable of becoming dangerous. He became President of the Council of Ancients in the month of July 1796; but left it in 1798. At the sitting of the 27th of April, he took leave of the Assembly in a speech which was ordered to be printed. He died on the 16th of March 1799, after a long and painful illness.

Dussaulx was a man of considerable literary attainments; and amiable, upright, and disinterested, in his conduct. His translation of *Juvenal* is esteemed the best version of that poet in the French language. His other works are:—*Memoires sur les Satiriques Latins. Lettres et Reflexions sur la fureur du Jeu, auxquelles on a joint une autre Lettre Morale*, Paris, 1775. *Discours sur la Passion du Jeu dans les differents Siècles. De la Passion du Jeu, depuis les temps anciens jusqu'à nos jours*, 1779, 8vo. *Vie de l'Abbé Blanchet*, prefixed to the *Apologues and Tales* of that author, Paris, 1784, 8vo. *De l'Insurrection Parisienne, et de la prise de la Bastille*, Paris, 1790. *Lettre au Citoyen Freron*, 1796, 8vo. *Voyage à Barrege, et dans les Hautes-Pyrenées*, Paris, 1796, 2 vols. 8vo. *De mes Rapports avec Jean-Jacques Rousseau*, &c. Paris, 1798, 8vo,—a curious work, which throws considerable light on the character of that celebrated man.

Marie-Jeanne Lieutau, the widow of Dussaulx, published Memoirs of his life, which are exceedingly interesting. See also Palissot, *Memoires sur la Litterature*; and *Biog. Universelle*. (H.)

DUTENS (LOUIS), a late French writer of some celebrity, was born at Tours, of Protestant parents, on the 15th of January 1730. In his youth, he addicted himself to poetry; and in 1748, he repaired to Paris and composed a tragedy, entitled, *The Return of Ulysses to Ithaca*, which he showed to the comedian Lanoue, requesting him to bring it on the stage. The latter, however, returned the piece, advising the author to retouch it. Irritated at this advice, Dutens went to Orleans, where he got his play represented with great applause; but he soon became sensible of the faults of his work, and abandoned a species of composition in which he found he was not born to excel. He soon afterwards went to England. Before leaving France, he accidentally became acquainted with Miss Pitt, sister to the Earl of Chatham, who gave him a letter to her brother; but after a short stay in London, he returned to France. Not long after, he was recalled to London by one of his uncles, to accompany a young English nobleman on his travels. Soon after his arrival, the young nobleman changed his intention; but, at the same time, he procured for Dutens the situation of a tutor in a private family. The father of the pupil was a man of considerable literary and scientific attainments, who instructed Dutens in those branches of knowledge in which he was deficient. In this manner he learnt Greek and mathematics; and he at the same time applied himself to the Oriental languages, and to Italian and Spanish. At the end of three years his pupil died; but one of his sisters being deaf and dumb, Dutens undertook to educate her. His young pupil, however, having become enamoured of her instructor, he deemed it a matter of delicacy and of duty to leave the house.

About this time he was appointed chaplain and secretary to the Honourable Mr Stuart Mackenzie, the English Minister at the Court of Turin, and left England in the month of October 1758. In 1760, when Mr Mackenzie returned to England, the Secretary remained at Turin as *Chargé d'Affaires*. Dutens came to England in 1762, and at-

Dutens.

tached himself to the family of Lord Bute, who, before he retired from office in 1763, procured him a pension. He again went to Turin, as *Chargé d'Affaires*, and during this second mission, he undertook the task of collecting and publishing a complete edition of the works of Leibnitz, and wrote his work on the *Discoveries of the Ancients*. He afterwards quitted Turin, returned to Britain, and attached himself to the Duke of Northumberland, who procured him a living in the north of England. He accompanied the Duke's son, Lord Algernon Percy, in his travels through France, Italy, Germany, and Holland; and while at Paris, he was chosen a Member of the Academy of Inscriptions. In 1776 he returned to England; and soon afterwards accompanied Mr Mackenzie and his lady on a tour to Naples. On his return, he was invited by Lord Mountstuart, who had been appointed Envoy Extraordinary, to accompany him to Turin, and Dutens found himself, for the third time, *Chargé d'Affaires* at that Court, during a short absence of the Envoy. From Turin, which he left on account of some unpleasant circumstances, he went to Florence, and from thence to Rome. He was in Paris in 1783, and returned to London the following year. The revenue he derived from his living of Elsdon, amounting to L. 800 *per annum*, together with a considerable legacy left him by Mr Mackenzie, and estimated at L. 15,000, enabled him to pass the remainder of his life in affluence, and in the best company. He died at his house, Mount-Street, Grosvenor Square, on the 23d May 1812.

Dutens was the editor of the works of Leibnitz, published at Geneva, 1769, in 6 vols. 4to; of the Greek pastoral romance of *Daphnis and Chloe*, by Longus, 1776, 12mo, and of Dacier's translation of the *Manual of Epictetus*, 1775, 18mo. He was also the author of the following works: *Le Caprice Poetique*, a collection of poems, 1750, 16mo; *Recherches sur l'origine des decouvertes attribuées aux Modernes*, 1766, 2 vols. 8vo. 4th ed. 1812; *Poesies*, 1767, 12mo, and 1777, 8vo; *Le Tocsin*, Rome, 1769, 12mo, reprinted under the title of *Appel au bon Sens*, London, 1777, 8vo. This work was directed against the French philosophers, and was published anonymously. *Explication de quelques medailles de peuples, de villes, et de rois, Grecques et Pheniciennes*, 1773, 4to. *Explication de quelques medailles du cabinet de Duane*, 1774, 4to. *Troisieme Dissertation sur quelques medailles Grecques et Pheniciennes, ou se trouvent des observations pour servir à l'etude de la paleographie numismatique*, 1776, 4to. Dutens, at the same time, published a more complete edition of the two preceding works. *Logique, ou l'art de Raisonner*, 1773, 12mo, 1777, 8vo, and reprinted also in his miscellaneous works. *Du miroir ardent d'Archimede*, 1755, 1777, 8vo; *Des pierres precieuses et des pierres fines, avec les moyens de les connaitre et de les evaluer*, 1776, 12mo, and reprinted at London and Paris. *Itineraire des routes les plus frequentées, ou Journal d'un Voyage aux principales Villes d'Europe*, 1775, 8vo, and frequently republished with additions and improvements. *Lettre à M. D. B. (Debure) sur la refutation du livre l'Esprit*, par J. J. Rousseau, 1779, 12mo, which contains some letters of Helvetius and Rousseau. *De l'Eglise, du Pape, de quelques points de controverse, et moyens de reunion de toutes les eglises Chretiennes*, 1781, 8vo; several times reprinted, and finally under the title of *Considerations Theologiques sur les moyens de reunir toutes les eglises Chretiennes*, 1798, 8vo. *Œuvres melées*, 1784, 8vo. Under the same title almost the whole works of Dutens were collected and published at London, 1797, 4 vols. 4to. *L'Ami des etrangers qui voyagent en Angleterre*, 1789, 8vo, frequently reprinted. *Histoire de ce qui s'est passé pour le retablissement d'une regence en Angleterre*, 1789, 8vo. *Recherches sur le tems le plus reculé de l'usage des Voutes chez les anciens*, 1795. *Memoires d'un Voyageur qui se repose*, Paris, 1806, 3 vols. 8vo. The two first volumes contain the life of the author, written in a romantic style; the third bears the title of *Dutensiana*, and is filled with remarks, anecdotes, *bons mots*, &c. Dutens is the author of the *Catalogue of Medals* in Swinburne's *Travels*, and of the French text to the second volume of the *Marlborough Gems*. There is a *Memoir* of his in the Collection of the Academy of Inscriptions, and he also published a small tract on the *Iron Mask*. He was a member of the Royal Society of London, and had the title of Historiographer to the King. See *Memoirs* of Dutens in the *Gentleman's Magazine* for 1812; Chalmers's *Biog. Dict.* and *Biog. Universelle.*

(H.)

Eberhard.

EBERHARD (John Augustus), an eminent German theologian and philosopher, was born at Halberstadt in Lower Saxony, on the 31st August 1739. His father was the singing-master at the church of St Martin's in that town, and also teacher of the school of the same name; a man, it is said, of a lively disposition, and considerable literary attainments. Young Eberhard was educated partly at home, and partly in the school above mentioned. In the seventeenth year of his age, he repaired to the university of Halle, with the view of prosecuting his theological studies. Towards the end of the year 1759, he returned to his native town, and became tutor to the eldest son of the Baron Von der Horst; to whose family he attached himself for a number of years. In the year 1763, he was appointed conrector of the school of St Martin's, and second preacher in the Hospital Church of the Holy Ghost; but he soon afterwards resigned these offices, and followed his patron to Berlin.

The advantages he enjoyed in this family of being introduced into the best company, tended to polish his manners, and to form, even at an early period, a style of writing, which served as a model to many of his contemporaries. His residence at Berlin gave him an opportunity of extending his knowledge, and of cultivating the acquaintance of some of the most eminent literary characters in Germany. Among these were Nicholai and Mendelssohn, with whom he associated upon terms of intimate friendship.

In the year 1768, he accepted the situation of preacher, or chaplain, to the Work-house at Berlin, along with that of preacher in the neighbouring fishing village of Stralow. The income from these livings was small; but his object was to continue at Berlin, and he had, at the same time, the promise of further preferment upon the first vacancy. He now applied, with renewed ardour, to the study of theology, philosophy, and history; and the first fruits of his talents and application soon appeared in his *New Apology of Socrates;* a work exhibiting such originality of thought and eloquence of style, as at once established his character as a writer. This work was occasioned by an attack which was made on the sentiments contained in the fifteenth chapter of Marmontel's *Belisarius*, by one Peter Hofstede, a clergyman of Rotterdam, who, with a contemptible industry, raked up the vices of the most celebrated characters in the pagan world, and even went so far as to maintain that the most virtuous among the heathen were no fit objects of divine mercy. He seemed particularly desirous to blacken the character of Socrates; and, from this circumstance, Eberhard was induced to give to his work the title we have mentioned above. The greater part of it is occupied with an investigation of some of those peculiar doctrines which have been admitted as dogmas of the Christian church, upon the authority of some of the early fathers; and an examination of those texts of scripture upon which they are founded. The *Apology* itself, which constitutes but a small part of the book, is esteemed a masterpiece of clear, dignified, and persuasive eloquence. The whole work exhibits much reading and philosophical reflection; but the liberality of his reasoning gave great offence to many of the strictly orthodox divines of his time, and is believed to have obstructed his preferment in the church.

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In the year 1774, he was appointed to the living of Charlottenburgh; and he employed the leisure he had in this situation in publishing a second volume of his *Apology;* in which he not only endeavours to obviate some objections which were taken to the former part, but continues his inquiries into the doctrines of the Christian religion, religious toleration, and the proper rules for interpreting the scriptures. Perceiving that his further promotion in the church would be attended with difficulty, he resolved, although reluctantly, to accept the situation of Professor of Philosophy at the University of Halle, which became vacant in 1778, by the death of G. F. Moier. But however excellent as a writer, and however just his ideas upon philosophical subjects, he does not appear to have been peculiarly qualified to excel as a teacher. He was highly esteemed, indeed, both by professors and students; but his lectures, although they attracted, at first, a considerable concourse, never acquired any degree of popularity. He continued. however, to lecture very regularly; and published several manuals for the use of his pupils.

On his arrival at Halle, the philosophical faculty presented him with a diploma as Doctor in Philosophy and Master of Arts. In 1786, he was admitted a Member of the Berlin Academy of Sciences; and in 1805, the King of Prussia conferred upon him the honorary title of a Privy Councillor. In 1808, he obtained the degree of Doctor in Divinity, which was given him as a reward for his theological writings. He married in 1778, but had no children. He died on the 6th of January 1809, in the 70th year of his age.

Eberhard's attainments in philosophy and literature were extensive and profound. He was master of the learned languages; spoke and wrote French with facility and correctness, and understood English, Italian, and Dutch. He had read a great deal; was thoroughly versed in the philosophical sciences, and possessed a just and discriminating taste for the Fine Arts. He was a great lover of music, and was himself a proficient in that science. His manners were mild and unassuming; and his amiable and cheerful disposition, no less than his

talents and his virtues, endeared him to a numerous circle of friends.

The following is a list of his works.

Neue Apologie des Socrates, &c. 2 vols. 8vo. The first volume was published in 1772, the second in 1778; both have been since republished.

Allgemeine Theorie des Denkens und Empfindens. &c. Berlin, 1776, 8vo. This essay obtained the prize assigned by the Royal Society of Berlin for that year. A new edition appeared in 1786.

Von dem Begriff der Philosophie und ihren Theilen, Berlin, 1778, 8vo. A short essay, in which he announced the plan of his lectures, on being appointed to the professorship at Halle.

Lobschrift auf Herrn Johann Thunmann, Prof. der Weltweisheit und Beredsamkeit auf der Universität zu Halle. Halle, 1779, 8vo.

Amyntor, eine Geschichte in Briefen. Berlin, 1782, 8vo. This work was written with the view of counteracting the influence of those sceptical and epicurean principles in religion and morals, which were then so prevalent in France, and from thence rapidly spreading among the higher ranks in Germany. It is composed with great elegance and perspicuity, and exhibits much philosophical reflection, and knowledge of the world. The story is simple, and seems to have been merely intended as a vehicle for the sentiments.

Ueber die Zeichen der Aufklärung einer nation, &c. Halle, 1783, 8vo. A lecture delivered at Halle, in presence of his Serene Highness the reigning Duke of Wurtemberg.

Theorie der Schönen Kunste und Wissenschaften, &c. Halle, 1783, 8vo. 3d ed. 1790.

Vermischte Schriften. Halle, 1784.

Neue vermischte Schriften. Ib. 1788.

Allgemeine Geschichte der Philosophie, &c. Halle, 1788, 8vo, 2d ed. with a continuation and chronological tables, 1796. Eberhard published also an abridgment of this work in 1794.

Versuch einer allgemeinen deutschen Synonymik, &c. Halle and Leipsic, 1795-1802, 6 vols. 8vo. This is esteemed a classical work on the Synonymes of the German Language. An abridgment of it was published by the author, in one large volume 8vo. Halle, 1802.

Handbuch der Aesthetik, &c. Halle, 1803-1805, 4 vols. 8vo.

Besides the works above mentioned, Eberhard contributed a number of small tracts and essays to various periodical and scientific publications; and translated several foreign works. He was also the editor of the *Philosophical Magazine*, Halle, 1788-1792; and of the *Philosophical Archives*, Halle, 1793-1795. These two periodical works, which are now little read, were instituted for the purpose of controverting the metaphysical principles of Kant, and of vindicating the doctrines of Leibnitz and Wolf.

Frederick Nicolai published a Memoir on the life and character of Eberhard, Berlin and Stettin, 1810, 8vo. See also K. H. Jördens, *Lexicon deutscher Dichter und Prosaisten*; and *Biog. Universelle.*

(H.)

ECONOMISTS.

THE philosophers, who are known to the world by this title, would deserve a longer article than we are able to bestow upon them. It is not, indeed, in general known, how much the Science of Politics, that master science, the late offspring of the improved reason of modern times, is really indebted to the Economists. They were, it is true, preceded in this country by Hobbes and by Locke, and in France by Montesquieu; but in analysing the frame of civil society, they added considerable lights to those which had been communicated by their predecessors; and they attempted to point out the mode of combining the various springs of social action in a more liberal and beneficent system than had yet been recommended to the world.

It is worthy of remark, that the merits of this sect, in the secondary department of *Political Economy*, have so much obscured their important speculations on the great questions respecting the best possible order capable of being given to society, that they are, in this country at least, wholly unknown, except in the character of political economists; though their political economy formed only a small and subordinate branch of their entire system; and, what is indeed extraordinary, we know not a book in the English language, in which an account of that system is to be found.

This article is intended to contain, 1*st*, the history of the sect; 2*dly*, an account of their system; and, 3*dly*, some observations, pointing out the principal errors into which they have fallen.

I. M. de Gournay appears to have been the first man in France who had formed any systematic notions on the real principles of trade. It is true, indeed, that Fenelon had recommended, on the direct suggestion of good sense, detached from theory, the practice of freedom of trade. The Marquis d'Argenson was celebrated for the sound and important maxim, *pas trop gouverner;* and the memorable advice of the merchants to the meddling Colbert was well known, *Laissez nous faire.* Another of the more peculiar doctrines of the Economists was expressed in the famous maxim of the great Duc de Sully, *Que le labourage et le paturage sont les mammelles de l'Etat;* and Montesquieu had brightly, but superficially, run over several of the questions relative to trade.

For such lights as M. de Gournay did not derive from his own reflections, he seems to have

been chiefly indebted to the writers of England; but there appears some reason to conclude, that the best of these had not fallen in his way. We do not perceive, for example, any sign of acquaintance with the writings of Locke.—It is worth mentioning here, as an historical fact, not very generally known, that there were some few minds in England, which, at a comparatively early period, had attained to wonderfully correct notions on the principles of commerce. Among the most remarkable of those ingenious minds were the Lord-Keeper Guilford and his brother, Sir Dudley North, an eminent merchant, in the reign of Charles II. There is a passage on this subject in the *Life of the Lord Keeper*, written by his brother, the Honourable Roger North, so interesting, that we deem it worthy of a place in the *History of Political Economy*.

"These brothers lived with extreme satisfaction in each other's society; for both had the skill and knowledge of the world, as to all affairs relating to their several professions, in perfection; and each was an Indies to the other, producing always the richest novelties, of which the best understandings are the greediest.

"And it must be thought, trade and traffic in the world at large, as well as in particular countries, and more especially relating to England, was often the subject. And Dudley North, besides what must be gathered from the practice of his life, had a speculative—extended idea; and withal, a faculty of expressing himself (however, without show of art or formality of words) so clear and convincingly, and all in a style of ordinary conversation, witty and free, that his lordship became almost intoxicated with his discourses. And these new notions did so possess his thoughts, and continually assume shapes and forms in his mind, that he could not be easy till he had laid them aside (as it were) upon paper, to which he might recur, when occasion was, to reconsider or apply them. But here having mentioned some new lights struck about trade, more than were common, it may be thought a *jejune* discourse, if I should pass on without giving some specimens of them; therefore, I add a note or two that I could not but observe. One is, that trade is not distributed, as government, by nations and kingdoms, but is one throughout the whole world, as the main sea, which cannot be emptied or replenished in one part, but the whole, more or less, will be affected. So when a nation thinks, by rescinding the trade of any other country, which was the case of our prohibiting all commerce with France, they do not lop off that country, but so much of their trade of the whole world, as what that which was prohibited bore in proportion with all the rest; and so it recoiled a dead loss of so much general trade upon them. And as to the pretending a loss by any commerce, the merchant chooses in some respects to lose, if by that he acquires an accommodation of a profitable trade in other respects; as when they send silk home from Turkey, by which they gain a great deal, because they have no other commodity wherewith to make returns; so without trade into France, whereby the English may have effects in that kingdom, they would not so well drive the Italian, Spanish, and Holland trades, for want of remittances and returns that way.

"Another curiosity was concerning money—that no nation could want money; and that they would not abound in it; which is meant of specie, for the use of ordinary commerce and commutation by bargains. For, if a people want money, they will give a price for it; and then, merchants for gain bring it and lay it down before them. And it is so where money is not coined; as in Turkey, where the government coins only pence or halfpence, which they call purraws, for the use of the poor in their markets; and yet vast sums are paid and received in trade, and dispensed by the government, but all in foreign money, as dollars, chequeens, pieces of eight, and the like, which foreigners bring to them for profit. And, on the other side, money will not superabound: for who is it that hath great sums and doth not thrust it from them, into trade, usury, purchases, or cashiers, where the melting-pot carries it off, if no use, to better profit, can be made of it? People may indeed be poor, and want money, because they have not wherewithal to pay for it; which is not want of money, but want of wealth, or money's worth; for where the one is, the other will be supplied to content." (North's *Life of the Lord-Keeper Guilford*, Vol. II. 13.)

Though the quotation is rather a long one, there is another passage in the *Life of Sir Dudley North* himself, also written by the same brother,—a passage so full of instruction, with regard to *practical politics*, as well as *speculative politics*, and with regard to the mode in which *practical politics* mends the blunders of *speculative*, that the present opportunity ought not to be lost of pointing it out to the attention of the world.

"There was a law passed, or rather was continued, this Parliament, called the coinage. This was a certain tax laid to pay for coining money, whereby any man who brought into the mint bullion, took out coined money, weight for weight. Sir Dudley North was infinitely scandalized at this law, which made bullion and coined money par, so that any man might gain by melting: as, when the price of bullion riseth, a crown shall melt into five shillings and sixpence; but, on the other side, nothing would ever be lost by coining; for, upon a glut of bullion, he might get that way too, and upon a scarcity, melt again; and no kind of advantage by increase of money, as was pretended, like to come out. The Lord Treasurer gave some of the banker goldsmiths and Sir Dudley North a meeting. Charles Duncomb, a great advancer, had whispered somewhat in his lordship's ear, that made him inclinable to the bill; Sir Dudley North reasoned with them against it, beyond reply; and then the answer was, *Let there be money, my Lord; by God, let there be money*. The reasons why this scheme prevailed were, first, that the crown got by the coinage duty; next, that the goldsmiths, who gained by the melting trade were advancers to the Treasury, and favourites. The country gentlemen are commonly full of one profound mistake; which is, that if a great deal of money be made, *they* must, of course, have a

share of it; such being the supposed consequence of what they call plenty of money; so little do assemblies of men follow the truth of things, in their deliberations; but shallow unthought prejudices carry them away by shoals!

"Another thing which gave him great offence was the currency of clipt money. He looked upon coined money as merchandise; only, for better proof and convenience, used as a scale, having its supposed weight signed upon it, to weigh all other things by; or as a denomination apt for accounts. But if the weight of it differed from its stamp, it was not a scale, but a cheat; like a piece of goods with a 'content' stamped, and diverse yards cut off. And, as to the fancy that common currency might reconcile the matter, he thought, that when a man takes a thing called a shilling, putting it off, it is also called a shilling, *nominally:* true, but, as to the deficiency, it is no other than a token, or leather money, of no intrinsic value, by what name soever it be called; and that all markets will be regulated accordingly; for, as money is debased, prices rise, and so it all comes to a reckoning. This was seen by guineas, which, in the currency of clipt money, rose to be worth thirty (clipt) shillings. Sir Dudley North was resolved, that if ever he sat in another Session of Parliament, he would bid battle to the public illusion. He knew, indeed, that he stood alone; and except some, and not many, of his fellow-merchants, scarce any person appeared to join with him. Corruption, self-interest, and authority, he knew, were winds that would blow in his face; but yet, he believed that his reasons were no less impetuous, and that he should be able to impress them; and that the business, being once understood, would make its own way. But the Parliament in which he served was dissolved, and he came no more within that pale. But, afterwards, finding that the grievance of clipt money became unsupportable, and with design that, since he could not, some other persons might push for a regulation, as well of this, as of some other grievances, relating to trade in general; and, to incite them to it, he put his sense in the form of a pamphlet, and, sitting the convention, or some time after it was turned into a Parliament, in 1691, printed it for J. Basset, and 'titled *Discourses upon Trade, principally directed to the cases of Interest, Coinage, Clipping, and Encrease of Money.*"

After mentioning that a reformation of the coin did subsequently take place, but not in the best manner, nor till many evils were sustained, he adds, "The honour had been much greater, if it had been carried by strength of reason, upon new discoveries, against the strongest prejudices, and interest mistaken, as Sir Dudley North intended to have done. And whether any use was made of his pamphlet or not, ... it is certain the pamphlet is, and hath been ever since, utterly sunk, and a copy not to be had for money; and, if it was designedly done, it was very prudent; for the proceeding is so much reflected on there for the worse, and a better showed, though not so favourable to abuses, as doth not consist with that honour and eclat held forth upon the occasion." * The complete extinction of this pamphlet is but too probable; for though the writer of this article has made search for it in every possible way, for several years, he has never seen it, nor met with an individual who had.

Jean-Claude-Maria Vincent, Seigneur de Gournay, was an extraordinary man for the age and country in which he was produced. He was born at St Malo in the month of May 1712, the son of Claude Vincent, one of the most considerable merchants of the place. Destined to commerce by his parents, he was sent to Cadiz when scarcely seventeen years of age. His vigilant attention to business did not hinder him from finding time, well husbanded, and diligently applied, not only for storing his mind with general knowledge, but for unravelling the combinations of commerce, and ascertaining its elementary principles. After he had raised himself to great eminence as a merchant, and to a high reputation for knowledge of the principles of commerce, the ministers of France conceived the design of turning his knowledge to advantage in the office of Intendant of Commerce, as they call it, to which he was raised in 1751.

No sooner was M. de Gournay invested with his office, than he began to wage war with the established system of regulations and restrictions; which the experience of twenty years of mercantile practice, the most varied and the most extensive—discussions with the most intelligent merchants of Holland and of England—the perusal of the best writers on the subject, and the impartial application of his own philosophical thoughts, had all conspired to make him regard as a source, not of national advantage, but of continual vexation and hardship to individuals, and of poverty to the state. "He was astonished," says M. Turgot, "to find that a citizen could neither make nor sell a commodity, without having purchased a privilege, by getting himself made, at a great expence, a member of some corporation; that if he made a piece of cloth, for example, of any quantity and quality different from those commanded in certain regulations, instead of being allowed to sell it to those purchasers whom such quantity and quality suited the best, he should be condemned to see it cut in pieces, and to pay a fine heavy enough to reduce a whole family to beggary. He could not conceive how, in a country where the succession to titles, to estates, and even to the crown itself, rested upon custom, and where the application of even the punishment of death was rarely guided by any written definitions, the government should have thought proper to fix by written laws, the length and breadth of each piece of cloth, and the number of threads which it ought to contain.—He was not less astonished to see the government take in hand to regulate the supply of commodities; proscribe one sort of industry, in order to make another flourish; shackle

* *The Life of the Hon. Sir D. North,* &c. By the Hon. Roger North, p. 179.

with peculiar restrictions the sale of the most necessary articles of subsistence; prohibit the storing of commodities, of which the quantity produced varies greatly from year to year, while the quantity required for consumption is pretty nearly the same; restrain the export and import of a commodity, subject to the greatest fluctuation of price; and dream of ensuring the plentiful supply of corn, by rendering the condition of the labourer more uncertain and more wretched than that of any other part of the community." (*Œuvres* de M. Turgot, III. 333.)

It may easily be imagined, that M. de Gournay would find himself encountered by opposition the moment he endeavoured to introduce his beneficial views into practice. The grand instruments of this opposition were certain words and phrases, which have been used to screen misrule, in every country in which the voice of reform has begun to be raised. M. de Gournay, says Turgot, was opposed, under the names of an "innovator," and a "theorist," for endeavouring to develope the principles which experience had taught him, and which he found universally recognised by the most enlightened merchants, of every part of the world, among whom he had lived. The principles, marked out for reprobation, under the title of the "New System," appeared to him to be exactly the principles of plain good sense. The whole of this system was founded upon the certain maxim, that, in general, each man is a better judge of his own interest, than another man to whom it is a matter of indifference. From this M. de Gournay concluded, that, when the interest of individuals is precisely the same with the general interest, the best thing to be done is, to leave every man at liberty to do what he likes. Now, he held it as impossible, that in commerce, fairly left to itself, the interest of the individual should not coincide with the interest of the community." The proof which M. Turgot gives of the fundamental proposition, that the interest of the individual and of the community in a free commerce are the same, we need not repeat; because it can neither be rendered more clear nor more cogent than it is already in works with which every person is familiar, who is at all conversant with political science.

"From this principle M. de Gournay concluded, that the sole duties of government with regard to commerce are: 1. To render to all the branches of industry that precious liberty, of which the prejudices of barbarous times, the proneness of governments to lend themselves to the gratification of individual interests, and the pursuit of a mistaken good, have conspired to deprive them: 2. To facilitate the exercise of industry and ingenuity to every member of the community, exciting thereby the greatest competition among sellers, and ensuring the greatest perfection and cheapness of the commodities sold: 3. To admit the greatest competition among buyers, by opening to the seller every possible market,—the sole means of encouraging reproduction, which hence derives its only reward: 4. To remove every obstacle by which the progress of industry is retarded, by depriving it of its natural reward."

It is to M. de Gournay, therefore, that Turgot ascribes the origin of political economy in France. "It is to the ardour," says he, "with which M. de Gournay endeavoured to direct to the study of commerce and of political economy, all the talent which he was able to discover, and to the facility with which he communicated the lights which he himself had acquired, that we ought to ascribe the happy fermentation which for some years has been excited on these important subjects; a fermentation which arose two or three years after M. de Gournay was Intendant of Commerce, and has since that time procured us several works calculated to wipe off from our nation that reproach of frivolity, which, by its indifference for the more useful studies, it had but too justly incurred."

Francis Quesnay was born in the village of Ecquevilli, in the year 1694. According to the *Nouveau Dictionnaire Biographique*, he was the son of a labourer, and confined till he was 16 years of age to the business of the field. According to M. Dupont de Nemours, the editor and commentator of the works of Turgot, and a zealous Economist, he was the son of a small proprietor, who cultivated his own little property; and he was eminently indebted to his mother for the fashion of his mind. Though he was educated as a physician, and rose to such eminence in his profession as to be first physician to the King, the early occupation of his mind on the business of agriculture, had given the current of his thoughts a permanent direction; and, when he was summoned to reflect on the sources of wealth by the discussions probably to which the speculations of M. de Gournay had given birth, agriculture was the object on which his attention was more particularly fixed. He produced several works on different points of the science and practice of medicine; and it was only at a late period of life, that his works on political economy appeared. His chief production on this subject, *Physiocratie, ou du Gouvernement le plus avantageux au genre humans*, was first published in 1768. Not only had the speculations which he broached, and which he propagated with much fervour and diligence, considerable success in the world, but he had the fortune to gain a considerable number of proselytes, who exerted themselves with an ardour for the diffusion of his doctrine, and with a devotion to the opinions of their master, which more resembled the enthusiasm of the votaries of a new religion, or that of the followers of some of the ancient philosophers, than the indifference with which new speculations in philosophy have on all other occasions been received in modern Europe; and which gave to the Economists more of the character of a sect or a school, than has appeared to belong to those who have in recent times concurred in any other system of philosophical opinion.

There was, in truth, in the system of M. Quesnay and the other Economists, many things well calculated to attract attention and excite enthusiasm. From a few simple principles, they deduced, as they imagined, by a chain of very close and imposing arguments, a system of changes which would easily be introduced, without the smallest interruption to the tranquillity and happiness of the existing generation, calculated to remove from society all the deformities by which it was overspread, and to communicate to the mass of human beings a

fulness of happiness hitherto altogether unknown. At this point, therefore, we may close the historical part of this article; for the success of the great work of Dr Adam Smith, in a short time, superseded the *political economy* of the sect; and after the political economy was discredited, the rest of their doctrines met with little regard. The memory of them, however, is well worthy of being preserved; and this task we shall now, in as few words as possible, endeavour to perform.

II. The Economists proceeded upon no Utopian plan, which supposes society to be composed of beings different from those with whom we are already acquainted. They took man as he is—a being having wants, and governed by the desire of avoiding pain, and obtaining pleasure.

Man must have subsistence. Upon this ground they first took their stand. This being allowed, it followed, of course, that whatever was the best means of obtaining subsistence, would command the operations of men, as soon as ever it was sufficiently known.

Of these means, the first and fundamental is the establishment of property. This they proved by convincing arguments. We cannot exist without consuming. The nature of man leads to a rapid multiplication of human beings, and the earth yields a spontaneous nourishment for only a few. To make food keep pace with population, labour must be employed upon the ground. Men would be born for no other purpose than that of destroying one another, if there were not means of increasing the quantity of food in proportion to those that were born. Labour, then, is one of the physical necessities of nature. But if labour be necessary, so is property, because, without property, there can be no labour.

The proof of this proposition is short and irresistible. Nobody would labour under an assurance, that he would derive no advantage from his labour. Nobody would labour without a certain probability that he should enjoy the fruits of his labour. Now, this is property. The only question, then, which remains is, what is the degree of assurance with respect to the fruits of a man's labour? In other words, what are the laws of property, which tend most to secure the benefits which human beings derive from their labour? This, said the Economists, is the object, and the end of our researches.

They proceeded in their inquiry by the following steps. As a means to this labour, on which every thing depends, a man must be free to use his natural faculties of labour—his muscular powers. This freedom they called *the property of his person.* As another means to the same end, he must be free to use exclusively, and to preserve, what he acquires by his labour. This they called his *moveable property.*

Here we see the origin of that to which men have assigned the names of *rights* and *duties*. The exclusive powers assigned to the man over his person, and over the fruits of his labour, are called his *rights.* To allow these exclusive powers, by abstaining from every act which would impair them, is called the *duties* of all other men. Here we see, also, that *rights* and *duties* are reciprocal; that they imply one another; that they are created together; and that the one cannot exist without the other. Destroy the *rights* of property in the man, you destroy, by the same act, the *duties* of other men to exclude themselves from what was called his property. Destroy, in the same manner, the *duties* of other men to exclude themselves from what was called his property, and you destroy, at the same time, his *right* to that exclusion. *Rights* and *duties* are, in fact, but different names given to the same thing, according as it is regarded under one or another of two points of view.

Another important concatenation is here also to be seen. *Rights* are advantages; things to be enjoyed. *Duties* are burthens, abstracted from things to be enjoyed. Why should men accept these burthens, submit to these duties? Why? but because they find their advantage in doing so. It is plain how they find their advantage in doing so, and there is, there can be, no other reason. Men submit to the *duties* of respecting other men's *rights*, that they may have *rights* themselves. It is good for them to have *rights;* there can be no rights without *duties.* It is better to have the *rights* submitting to the *duties*, than by renouncing the *duties* to have no *rights.* The *duties* are then the price which is paid for the *rights.* The *duties* which one man yields to other men, are the price which he pays for having *rights* of his own. *Duties*, then, are in themselves *evils;* and they never ought to exist, except when they are compensated by a greater good. Nobody ought to be subjected to a burthen, which is not either to himself, or to the community in which he has clubbed his private interests, attended with a good, sufficiently great, to overbalance the evil which he is made to endure. *Utility*, then, is the exclusive foundation of *duty.*

Having laid this foundation, the Economists proceed.

On the necessity of subsistence rests the necessity of property, and on the necessity of property rests the necessity of a certain inequality in the conditions of men. This inequality exists, because a good is obtained through it, which can in no other way be obtained; and that good, the parent of every thing else to which the name of good is applied. "Those who complain of it," says Mercier de la Riviere, one of the chief expositors of the doctrines of the sect, "see not that it is a link in the chain by which the human species must drag from the abyss of non-production every thing which they enjoy. As soon as I have acquired the *exclusive* property of a thing, another man cannot have the property of it at the same time. The law of property is the same for all men; each man, however, acquires in proportion to his faculties of acquiring: but the measure of these is different in different men. And besides this fundamental law, there is, in the whirlpool of accidents, a continual succession of combinations, some more, some less fortunate, which increase the causes of that inequality of acquisition, without which the motives to acquisition cannot exist. . . . .
"I admit, however," he in conclusion adds, "that in any given community, these differences in the

possessions of different men, may become the source of great disorders, and which augment again these same differences beyond their natural and necessary degree. But what follows from this? That men ought to establish an equality of conditions? Certainly not; for to that end, it would be necessary to destroy all property, and, by consequence, all society; it only follows that they should correct those disorders which make that which is an instrument of good, become an instrument of evil; which alters in such a manner the distribution of things, that *force* places all the rights on one side, and all the duties on the other."

We have seen that the necessity of labour to procure the means of life, and the means of enjoyment, produced a necessity of *property personal*, and *property moveable*, as the two sorts were named by the Economists. The necessity of raising food, as well as the first material of most of the other articles of human enjoyment, by labour upon the *land*, produces a like necessity of creating a *property in the soil.* The proof of this proposition is not less short and convincing, than that which regards the other species of property. To make the land yield a produce useful to man, it must be cleared of many incumbrances, and prepared with much labour and expence. No adequate return can be obtained for this labour, to the man who would bestow it, without a perpetuity of possession. It is essential for the well-being of the species, that the labour should be yielded, and in the greatest degree of perfection. It cannot be yielded, perhaps, at all, certainly in no tolerable degree of perfection, without that exclusive possession which constitutes property. Property in land is, therefore, essential to the well-being of the human species.

We see in this manner what are the *rights*, and what are the *duties*, which the supply of the first wants of human nature renders it necessary to constitute. But as all mankind are not disposed to respect *rights* and *duties*, it is necessary, in order to obtain the advantages which they are destined to produce, that measures should be taken to protect them.

The measures taken to protect them are generally comprehended under one name, that is, *government*. The protection of the rights, or, which means the same thing, the insuring of the duties, is the *end*, the government is the *means*; and the question is, what combination of means is best adapted to the purpose?

This assuredly is the most important question to which the human faculties can be directed. And the Economists have never yet received the credit, which is their due, for the ability and success with which they laboured to resolve it. No speculations can be conceived of more importance than those in which they engaged, nor has it yet become easy to throw upon them a greater portion of light.

The grand classes of means by the skilful combination of which they conceived that the end might be obtained, were either more direct, or more indirect. The more indirect were liberty and evidence; the more direct—laws exactly adapted to the end, magistrates exactly adapted to the execution of these laws, and a Supreme, or, as they called it, "*Tutelary Power*." We shall endeavour, in a few words, to communicate their leading ideas on each of these particulars.

1. *Liberty.* We have seen that the end which is aimed at through property, as a means, is the greatest possible abundance of the things adapted for human enjoyment; and that property is a means altogether indispensable for that end. It is now to be proved, that liberty is absolutely necessary to enable property to answer the purpose of a means to that end; and that, without liberty, the existence of property is deprived of almost all its advantages. In fact, the right which a man has not the liberty to enjoy, is not a right. The right of property in a man's person, in his moveables, in his land, is the right of enjoying; but the *right* of enjoying, and the *liberty* of enjoying, are the same thing. Liberty, therefore, cannot be hurt without damaging the right of property; and the right of property cannot be hurt without damaging liberty. "It is," says Mercier de la Riviere, "so inseparably connected with the right of property, that it is confounded with it, and that the one cannot exist without the other. Deprive a man," he cries, "of all the rights of property, and I defy you to find in him a vestige of liberty. On the other hand, suppose him deprived of every portion of liberty, and I defy you to show that he truly retains every right of property."

It is now pretty clear that liberty is necessary to produce that abundance of production which is the end aimed at by the constitution of all *rights* and *duties.* Man is excited to labour, only in proportion as he is stimulated by the desire of enjoying; but the desire of enjoying can only be a motive of action in so far as it is not disjoined from the liberty of enjoying. You cannot have productions in abundance, without the greatest possible inducement to labour;—you cannot have the greatest possible inducement to labour, without the greatest possible liberty of enjoyment. The chain of evidence is, therefore, complete.

"Let us not," say the Economists, "seek in men, beings which are not men. Nature has destined them to know only two springs of action, or moving powers; the appetite of pleasure, and the aversion to pain. It is in the purpose of nature, therefore, that they should not be deprived of the liberty of enjoying, since, without that liberty, the first of those two powers would lose the whole of its force. *Desire of enjoying, Liberty of enjoying;* these are the soul of the social movements; these are the fruitful seed of abundance, because that precious combination is the principle of all the efforts made by human beings to procure it."

2. *Evidence.* Property, and by consequence liberty and security of enjoying, being proved to constitute the essence of what they called the natural and essential order of society, it was seen to be in reality a chain of *physical* consequences, involving nothing arbitrary, nothing changeable; evident, on the other hand, simple, and resting on no other ground than that of being the most advantageous possible to the whole body of the community, and to every one of its members.

"The best possible order of society, however,"

they observed, "cannot be established where it is not sufficiently known; but for that very reason, that it is the best order, the establishment of it, as soon as it is known, must become the common ambition of men; it must then introduce itself by *necessity;* and, once established, it must, by *necessity,* continue for ever." These were bold promises; but the proof was correspondent. "The best possible order of society must introduce itself, as soon as known, and preserve itself for ever, as soon as introduced; because the appetite of pleasure, and the aversion to pain, the only moving powers within us, lead naturally and constantly toward the greatest possible augmentation of enjoyments; and the desire of enjoying implies, by necessity, that of the means by which enjoyment is procured. It is, then," said the Economists, "impossible that men should know their best possible condition, without a consequent union of all wills, and all power to procure and to preserve it. Imagine not," they cried, "that for the establishment of this essential order, it is necessary to change the nature of men, and divest them of their passions; their passions, on the other hand, become auxiliaries in this establishment; and, for the most complete success, it is only necessary to place them in a condition to see with *evidence* that it is in this order alone they can find the greatest possible sum of enjoyments and of happiness."

These philosophers made some admirable observations upon the nature of evidence, and the important purposes to which it is subservient. They made a distinction between those propositions which a man receives without evidence, and those which he only receives upon the strength of evidence. The first they denoted by the word *opinion;* the second they marked by the names of *knowledge* and *certainty.* "As error," they said, "is every thing which is not truth; in like manner, what is not *evidence* is only *opinion;* and whatsoever is only opinion is arbitrary, and liable to change. It is evident, therefore, that these opinions are not a sufficient foundation for the natural and essential order of societies. A solid edifice cannot be erected on a basis of sand; and that into which nothing arbitrary can enter, which is and must be unchangeable as the ends to which it is directed, can never be founded on a principle so arbitrary and various as opinion; opinion, which, however just and true it may accidentally be, so long as it is not founded on evidence, is but opinion still, and liable every moment to be subverted and expelled by any other opinion, however extravagant and absurd."

Evidence is the knowledge, clearly attained and possessed by ourselves, of all that is necessary to see the truth or falsehood of an object of belief. This excludes all doubt, all uncertainty, every thing arbitrary, all exercise of will. A man can no more help believing that which he actually holds in his mind evidence sufficient to prove, than he can help seeing the object which is painted on his retina.

From this irresistible power of evidence the Economists deduced the most important consequences. "Not only is it," they said, "the essential characteristic of evidence, to stand the test of the most severe examination, but the most severe examination can have no other effect than that of displaying it to more advantage; that of giving to it a power more predominating and supreme: while, on the other hand, sufficient examination destroys prepossession and prejudice, and establishes in their place, either evidence, or at least suspension of judgment, where evidence, on which to found a judgment, is out of our reach."

On the first of these propositions, that "evidence can stand the test of the most severe examination," they said, "that all attempt at proof was surely unnecessary; it was self-evident. And hence," they said, "was evidently deduced this most important consequence, 'that the liberty of examining, of criticising, and of contradicting evidence, is always, and necessarily, without inconvenience.'

"That a sufficient examination destroys prepossession and prejudice," they regarded as a proposition equally indisputable: and from this it followed, as an irresistible consequence, "that the most unbounded liberty of examination and contradiction is of primary and essential importance; for no examination can be *sufficient,* till all the reasons of doubt are exhausted."

"That a sufficient examination establishes evidence in the place of error in the case of all questions where evidence is within our reach," was a truth, they said, resting on the same immoveable basis; and from this it followed, as an evident consequence, "that liberty of inquiry will lead by necessity to the clear and public knowledge of what is the best possible order of human society; for on this subject, evidence is undeniably within our reach."

"We may thus regard evidence as a sort of beneficent divinity, whose pleasure consists in spreading peace on earth. Never do you behold mathematicians at war with mathematicians on account of the truths which they have established on evidence; if they give into a momentary dispute, it is only while they are yet in the avenue of inquiry, and have investigation solely in view; but as soon as evidence has pronounced, either on the one side or the other, every man lays down his arms, and only thinks of enjoying in peace the good which is thus acquired in common."

"Pass now," say the Economists, "from the evidence of *mathematical* to that of *social* truths; to the evidence of that order of human affairs in society which would produce to men the greatest possible amount of happiness. From the known effects of evidence in the first of these cases, try to conceive what would be the effects of it in the second; what would of *necessity* be the internal condition of a society governed by that evidence; what would of *necessity* be the political and respective situation of all nations, if they were illuminated by its divine effulgence; consider, if men, rallied under the standard of that evidence, would have any division among them; if any motive for war would be sufficiently powerful to make them sacrifice to it their best, and to themselves *evidently* best possible condition: penetrate still deeper, and see if the pictures which that medium presents to you do not excite in you sensations, or rather transports, which elevate you above yourself, and appear to indicate, that, by

means of evidence, we communicate with the divinity.

"But, to increase your sensibility to the impressions which those pictures will make upon your understanding and your heart, place in opposition all the inconveniences which, in a state of ignorance, arise from the force of *opinion*.

"A certain thing is forbidden under the sanction of punishments capable of inspiring the greatest terror. What power can such prohibition and punishments have against an opinion which tends to despise them? None; we have too many examples to prove it.

"A man is placed by his birth in a situation in which he might effect the happiness of a great number of other men, if he made a beneficent use of his advantages; What is it the man performs when his *opinion* is wrong? He sacrifices his advantages to the disorder of his opinion; lives and dies unhappy.

"One man, unarmed, commands an hundred thousand with arms in their hands, of whom the weakest is stronger than he. What constitutes his power? Their opinion; they obey him in obeying it; they follow their leader because they have an opinion that they ought to follow him.

"Do you wish to see other effects which characterize the force of opinion? Consider the effects of honour; of that sort of enthusiasm which prefers toil and fatigue to repose, poverty and privation to riches, and death to life, on which it finds the secret of shedding a lustre.

"*Opinion*, of one sort or another, governs the world. Even when it is but a prejudice, an error, there is no power in the moral world comparable to its power. Fruitful in phantoms, it borrows all the colours of reality, in order to deceive. Source inexhaustible of good and of evil, it is through it alone that we see, by it alone that we will, and we act. According as it borders upon truth or falsehood, it produces virtues or vices, the great man or the villain. No danger stops it; difficulties render it more intense; at one time it founds empires, at another destroys them.

"Every man is therefore a little kingdom upon the earth, governed despotically by opinion. He will burn the temple of Ephesus, if it is his opinion that he should burn it; in the midst of the flames he will brave his enemies, if his opinion is that he ought to brave them. Our physical powers themselves are so completely subordinate to the power of opinion, that, to have the command of our physical powers, it is necessary to begin by having the command of our opinion; but how is it possible to have the command of opinion, while it is the sport of ignorance, and its nature arbitrary? How is it possible to fix and to unite the opinions of men, but by the agency of evidence? Is it not visible, that the Author of nature has appointed no other means for chaining our arbitrary will?

"We ought to look, therefore, upon ignorance, as the necessary principle of all the evils which have afflicted society; and upon the knowledge, that is, the evidence of the best possible order of society, as the natural source of all the good which is destined for the inhabitants of the earth.

"But, as all the physical forces in the world cannot render that evident which is not so; and as evidence can spring from nothing but *adequate examination*, from the necessity of that evidence clearly follows the *necessity of examination*; from the necessity of examination clearly follows the necessity of the *greatest possible liberty of contradiction*; and in addition to that liberty, the existence of all those political institutions which are required to give to evidence its greatest possible *publicity*."

The *publicity of evidence* was a subject on which the Economists dwelt with peculiar emphasis; and which they branched out into a number of the most important consequences. "The necessity of it," they said, "was apparent from this, that the proper order of society cannot be solidly established, but in proportion as it is sufficiently known. In any society, if some men only had knowledge and evidence of this order, while the multitude rested in other opinions, it would be impossible for this order to govern; it would in vain command; it would not be obeyed. This state would be that of a perpetual intestine war of one part of the nation with another. By *intestine war* they did not, however, mean," they said, "only that which is performed with arms in the hands, and by open force; they more peculiarly referred to those disguised and clandestine ravages and oppressions, exercised under forms of law; to those dark and predatory practices, which sacrifice all the victims which artifice is able to bring within their power; to all those disorders, in a word, which tend to make all particular interests enemies of one another, and thus to uphold, among the members of the same political body, an habitual war of clashing interests, the contending effects of which tear in sunder all the bonds of society. This situation is so much the more dreadful, in as much as, excepting the superior and governing force of evidence, there is no power in nature equal to that of opinion; as, in its aberrations opinion is tremendous, and as no means exist, by which we can make sure of retaining it always within proper limits, when it is once given up to its own inconstancy, and to seduction.

"From the *publicity*, which is an indispensable condition to possession of evidence respecting what is best in the social order, we are conducted to the necessity of *public instruction*. Though faith," said the Economists, "be the gift of God, a peculiar grace, which cannot be the work of men alone: nevertheless it is held that the preaching of the gospel is peculiarly necessary to the propagation of the faith. Why, then, should not every one have the same opinion with regard to the publication of the social order, more especially as that publication has no need of being aided by grace and supernatural light? This order is instituted for men, and all men are born to live under it; it is then required by this order that men should know it, and accordingly they have all a sufficient portion of natural faculties, to be able to elevate themselves to that knowledge. For the same reasons that knowledge is required, instruction is required, by which alone certain kinds of knowledge can be attained."

The Economists did not enter into details respecting establishments necessary for instruction. They,

however, affirmed, that such establishments "constituted a part of the essential form of a society, and that they could hardly be too numerous, because instruction can never be too common." They affirmed, also, that "verbal instructions did not suffice; that it was necessary to have doctrinal books, suited to the purpose, and in every body's hand. This help," they said, "was so much the more important, as it was clear of all inconvenience, for error cannot stand the presence of evidence; and contradiction is not less advantageous to evidence, than it is fatal to error, which has nothing to fear so much as examination."

What they affirmed with respect to the necessity of those which they called doctrinal books, and of the liberty which ought to reign with regard to them, "was founded," they said, "upon the very nature of that order which is due to society, and of the evidence which belongs to it. That order," they observed, "is either perfectly and evidently known, or it is not. In the first case, its evidence and simplicity render the formation of heresies on the subject of it altogether impossible. In the second case, men cannot arrive at knowledge or evidence, but through the conflict of opinions. It is certain that an opinion can be established only upon the ruins of those which are opposed to it; it is further certain, that every opinion which is not founded upon evidence will be contradicted, until it is either destroyed, or recognised on evidence for a truth, in which case it ceases to be a bare opinion, and becomes an evident principle. And thus, in the pursuit of truths, capable of being established on evidence, the conflict of opinions leads, of necessity, to evidence, because it is by evidence alone it is capable of being terminated."

This doctrine is of such infinite importance, that we are willing to prolong it, by adding the illustration which the Economists were accustomed to adduce. "If a man should be actuated by any motives to write a book, endeavouring to persuade his countrymen that they might live without subsistence,—that they ought to make commodities without the materials,—that they multiply themselves by change of place, or any other extravagant opinion; it would be highly useless for the public authority to give itself any concern or labour to prevent such a book from making an impression upon the public mind. And, far from feeling any alarm, every body would rest securely upon the evidence of the contrary truths; assured that this evidence would always be sufficient for itself, and would quietly triumph over all the ridiculous efforts which would be made to oppose it.

"So absolutely necessary is it to leave to the whole body of society the greatest possible freedom of examination and contradiction; so absolutely necessary is it to abandon evidence to its own strength, that there is no other power which can supply its place; physical power, of what magnitude soever, can command actions alone, never opinions. The experience of every day affords to this truth the evidence of the senses. So little have our physical powers any influence over our opinions, that our opinions, on the contrary, exercise an uncontrollable dominion over our physical powers. Our physical powers are put in motion, and guided by our opinions alone. The common or social, called the *public force*, is formed by the union of the physical powers of many individuals. This supposes, necessarily and invariably, a correspondent union of evils; and this can never exist but in consequence of an union of opinions, good or bad. It is, therefore, to reverse the order of things, and take the effect for the cause; to desire to give the public force a power over opinion, while it is from the union of opinions that public force holds its own existence; and while, by consequence, it can have no stability but in proportion to that which reigns in the opinion on which it is founded; that is to say, in proportion as bare opinions, stript of evidence, are replaced by opinions fixed and invariable, because founded upon evidence which cannot deceive."

3. *Laws.* Having established as incontrovertible truths, that property is necessary to the production of the means of human life and enjoyment; that the system of human rights and duties spring from it as natural consequences, and that the natural and essential order of societies is nothing in reality but the chain or connected order of these same rights and duties, the Economists laid down the following definition: "That the Essential Form of a Society is the continuation of all those social institutions which are necessary to consolidate the right of property, and secure to it all the liberty which essentially belongs to it."

Among these instrumental establishments, an important place is held by laws, of which they communicated the following very striking and original idea:

"A multitude of men assembled without acknowledging any respective rights, any reciprocal duties, would not form a society. That does not consist in the meeting of a number of men in a particular place. It may subsist among men very remote in respect of place, and not subsist among men very near in respect of place. *That which really constitutes the union, are the conditions of the union.* These conditions are the systems of rights and duties, in other words, the conventions entered into for their common interest by the members of the associated body. The laws, then, are precisely those conventions; by operation of which, the reciprocal rights and duties are established in such a manner that the members of the society are no longer permitted, arbitrarily, to depart from them.

"Of these conventions, some are of such a nature as cannot be defined very exactly, or at least cannot be enforced by artificial sanction, but must be left to the natural coercion of the approbation and disapprobation of mankind. Such are the common duties of morality; gratitude, veracity, charity, and the like. But the next class of these conventions are those which are capable of being defined exactly, and enforced by artificial sanctions; as, that murder shall not be committed; property shall not be stolen. This last class of conventions are those which are properly called *laws*.

"The first property necessary to give those laws their best possible *form* (for, in regard to their sub-

Economists. stance, it is always supposed that they are strictly conformed to that utility, from which the whole system of rights and duties takes its origin), is, that they be definitive: to distinguish, by an incontrovertible line, what each of them does, from what it does not comprehend. This is implied in the very notion of a law; which is to render something *positive*, which would otherwise be *arbitrary*.

"The second property necessary to give laws their best possible form, is, that they be written. This is, indeed, implied in the first property; because no combination of ideas can be rendered *positive* and *unvarying*, of which the *expression* is not *positive* and *unvarying*. But nothing can render an expression positive and unvarying, but a permanent sign; and of permanent signs, none is equal to writing.

"The third property necessary to give to laws their best possible form, is, that the reason of each be annexed to it. The distinction is very important between the *letter* of the law, and the *reason* of the law. The *letter* of the law is its textical composition; the *reason* of the law is the motive by which it was dictated. *The man who is guilty of murder shall receive a certain punishment.* This is the *letter* of the law. The *reason* is, that, *if murder were common, and not restrained by adequate motives, the happiness of human beings, if not the species, would soon be destroyed.* Having thus acquired a knowledge of the reason of the law, I possess the *evidence* of its *utility*. And of this I should not have been possessed, had I seen in the law nothing more than the *letter*. Let us suppose two laws, which equally assign the punishment of death; the one for homicide, the other for walking at certain hours in the day. Is it not clear that they would be viewed with different eyes; that the one would appear to be just, the other tyrannical? That we should feel within ourselves a natural disposition to submit to the one, a disposition to avail ourselves of every thing which might serve as a means to deliver us from the hateful yoke of the other. This difference arises from the different judgment we form of the *reason* of these bad laws. The first carries with it the *evidence* of its *utility*; and that *evidence* overcomes and binds without resistance the understanding and the will. The other carries with it, instead of the evidence of utility, the evidence of nothing but a disproportional rigour, of a manifest evil, to which our understanding, and consequently our will, can never submit.

"It is not, therefore, in the *letter*, but in the *reason* of the laws, that we must seek for the first principle of a constant submission and obedience to the laws; for that principle can be nothing but the dominion exercised over our minds by the *evidence* of the justice of necessity, that is, the *utility* of the laws; now this evidence is not in the *letter* of the laws: to establish that submission, therefore, generally and invariably, two conditions are requisite; one is, that the reason of the laws contain conclusive *evidence* of their *utility*, commonly called their justice and necessity; the other is, that the publication of this evidence be so complete, in respect both of clearness and diffusion, as to lodge it in the mind of a majority of all classes of the people. Men, persuaded that their laws were bad laws, might, indeed, for a time be constrained to observe them; but such a submission, contrary as it is to nature, could not be durable, nor escape daily breaches on the part of those who regarded themselves as suffering by the injustice of the laws. *Submission to the laws is always, and necessarily, proportional to the idea which we hold of their justice and necessity*: that is, their indispensable use in procuring good and eschewing evil.

"If laws," said the Economists, "are any thing but the results of the natural order of society, or of that system of duties and rights which are rigidly founded upon the interest of all; if the legislature of any country sets up rights and duties of another sort, these new rights and duties are contrary to the first; and hence, of necessity, the laws which prescribe them are in a state of perpetual opposition with our understandings and wills." This contrariety they proved in the following manner. "All the rights which a reasonable being can desire, are summed up in that of property; because from the right of property results the liberty of enjoying; a liberty which ought to have no bounds but those which are assigned to it by the similar rights of property belonging to other men. As the essential order of society thus determines the measure of liberty belonging to each of its members, and as that measure is the greatest which can be, without disturbing that essential order itself, it is impossible that any thing should be added to the liberty, that is, to the rights of one set of men, without taking from the liberty, and by consequence from the property, of other men; and this is an injustice, and disorder, the tendency of which is destructive to the society."

It is destructive to the society, because it throws it into a state of violence. "My neighbour," says Mercier de la Riviere, "will be content that he is not allowed to reap or to injure my crop; but for the same reason he will not be content that I should be allowed to reap or to injure his. On the view of such an injury permitted, in regard to any other man, he will take the alarm, his fears will be excited for himself, and this anxiety will be a state of torment, from which his reason will perpetually urge him to seek relief. A law which violates the principle of utility, is a law therefore resisted by that evidence which governs beyond control the human will. To make such a law, is to put the society into a state of violence; because it is to put the minds of men into a state hostile to one another, and more or less hostile to the laws.

4. *Magistrates.* By this term the Economists understood judges, and, in a word, all the leading functionaries employed in giving execution to the laws. Agreeably to the doctrines already exhibited, they conceived that the first service of the magistrates, is that of shedding the light of *evidence* upon the particular cases, which have been too obscure for the parties. But as there are some minds with which you cannot be sure of being able in every case to bring evidence, as it were, in contact, the magistrate needs to be armed with a coercive power; and all that is necessary is, that he affords to the rest of the community *evidence* that in

such cases, the power has been used agreeably to the principle of general good.

From these premises, the chief consequence which they deduced was, that the legislative and judicial powers are never to be united in the same hand, without destroying among the people all certainty of the justice and necessity of their laws, that is, the very essence of the laws themselves.

" The essential form of positive laws," they said, " in that which makes them to be what they ought to be, is, that they consist of certain visible signs which show that, in the institution of them, that order has been followed, which is necessary, 1*st*, to ensure their justice and necessity, that is, their adaptation to the ends of obtaining good and avoiding evil; 2*dly*, to render their adaptation to those ends evident or certain to the individuals whom they concern. Now it is clear, that these conditions could not be fulfilled, if the legislative power was to engross the judicial functions. The legislator and judge, being the same person, neither could the legislator find any resource against his own mistakes in the close review and experience of the judge; nor, on the other side, could the arbitrary will of the judge find any bridle or chain in the authority of the legislator; but the laws, however good in themselves, would be rendered evil by a variable and corrupt administration.

" If the legislator were judge also, his business would be to consummate and to crown all the mistakes which he incurred, or the abuses which he committed in the formation of the laws. If the judge were legislator also, the laws existing only in conformity to his will, he would be under no necessity to consult the laws in passing his judgment; and would always ordain as law-maker, what he should have to determine as law-interpreter. Thus, the *reason* of the positive laws would be found to consist in nothing but the will of the legislator, as he would be guided in making them by nothing but its arbitrary impulses; and in the same manner the *reason* of the judicial decisions would be found to consist in nothing but the mere will of the judge, whose independence would enable him to make them whatever he pleased. This double malady abundantly proves, that those laws would be stript of the essential characteristics of law, the evidence of their justice and necessity, and an absolute exemption from every thing arbitrary."

The duties of the judge they deduced in the following order: As the laws are in themselves mute, and the magistrate is the organ through which they speak, he is particularly charged with the *guardianship* of the laws. It is of importance to know what is implied in the term guardianship of the laws. It relates either to the laws which *are* made, or to those which are *to be* made. The natural strength of the laws consists in the evidence of their goodness. Their weakness consists in the strength of the hands which dispose of the physical power. As the laws are mute in themselves, they cannot wield that evidence in which their strength consists. The magistrates, who are the mouth of the laws, ought, therefore, to wield it for them, and to resist the hands in which the physical power is deposited, when they attempt the infringement of the laws, with all the force which evidence can be made to exercise over the minds of the community.

The same principles demonstrate what are the duties incumbent on the depositaries of the judicial power with regard to laws *to be* made. As laws ought all to be founded on that concatenation of the causes of human good which the Economists denominated " the primary and essential reason of all laws; the *evidence* of that primary and essential reason was," they said, " a deposit, so to speak, in the hands of the judicial instruments, of which they owed an account, to the legislature, to the nation, and to God himself, of whose supreme will that evidence is the decisive token. It was their first duty, therefore, to have a perfect *knowledge* of that primary and essential reason." Their next duty was, on all occasions, as far as their utmost efforts could extend, to impart that evidence to the governing power; and to make it as clear as it can be made, what laws, not yet proposed, that evidence shows that the society requires.

The Economists farther affirmed, " that no man can, without rendering himself criminal towards earth and heaven, undertake to perform the office of judge, according to laws that are *evidently* unjust. He would, in that case, cease to be a minister of justice, in order to become a minister of iniquity. If any law, for example, ordained that a man should be condemned to the ultimate punishment, on the mere denunciation of another man, and without any inquiry into the truth of the allegation, is it not evident, that such a law would be a law of murder? And is it not equally evident, that the barbarian, who should pronounce a judgment agreeably to that law, would be the voluntary instrument of murder? It is necessary, however, either to go the full length of saying, that a man can, without guilt, become the instrument of such a law, or allow that no minister of the law ought to lend his ministry to the execution of a law evidently unjust; for if he may, for one such law, so he may for all, however atrocious; no outrage to humanity, no excess of evil, presents any limiting point."

5. The *tutelary authority*. " The union of wills to form that of individual powers; the union of individual powers to form a common or public force; the deposit of that force in the hands of a chief, by whose ministry it may command, and make itself obeyed,—these," said the Economists, " are the component parts of the tutelary authority. The tutelary authority is nothing more than a physical force resulting from an union of wills; and, by necessary consequence, it is impossible for it to be either powerful or secure, unless the intuitive and determining force of evidence be the principle of that union.

" In one sense, it may be affirmed, that the right of commanding belongs to evidence alone; for, in the order of nature, evidence is the only rule of conduct bestowed upon us by the Author of nature. But all men are not equally capable of seizing evidence; and even if they were, the interest of the moment often operates upon them with such vehemence, that the appetite of enjoyment will not, in a state of disorder, be restrained by the evidence of

duty. Among human beings, therefore, it is necessary, that the natural authority of evidence be armed with a physical force; and that the legislative power, though it commands in the name of evidence, have the disposal of the public force, to ensure obedience to its injunctions."

From the analysis of what is necessary to constitute the tutelary authority, the key-stone, as it were, of the arch of human society, that which gives to the whole its binding force, and retains the parts in their order, the Economists deduced a variety of most important conclusions, of which we can only present the more striking as a sample.

The first is, That the legislative and executive powers are essentially inseparable; and that all the fine-looking theories, which have solicited and obtained so much of the admiration of a superficial world about the virtues of their separation, are phantoms in the air, the mere visions of imagination. "To dictate laws is to command; and as our passions render it impossible, that commands should be more than useless sounds, without the physical power of making them obeyed, the right of prescribing laws can have no existence without the physical power of enforcing them. The depositary of the power is, therefore, and necessarily, the master of the right; and the executive power is always and certainly the legislative power. Let the enemies of this conclusion turn and torture the subject which way they please, they never can escape from it. Suppose, in order to form two powers, that the legislative right is confided to one organ, the public force to another, when opposition arises, which of the two is to be obeyed? As it is impossible that two contradictory commands can be obeyed at the same time, it must be absolutely decided which of the two is in preference to be obeyed. Now, this decision is, by the very fact, the destruction of the other power, and the establishment of that one. These two powers, therefore, unavoidably run into one; the legislative power necessarily becomes the executive power, or the executive becomes the legislative.

The second is, That the legislative never has, never can have, a right to make *bad* laws. A right to make bad laws, they said, is a contradiction in terms. A right supposes a *compact*; it is the offspring of an agreement, tacit or express; the idea of it can no more exist without that of a mutual convention, than a debt without the contract of debtor or creditor. The compact upon which all rights are founded is that of mutual advantage; it is the union of all wills, freely determined by a great interest, of which the *evidence* is visible to all. How can that union, which only exists for the sake of a good, continue to exist, if it is seen to produce evil? The hope cannot be framed, of maintaining it by force; because force is its effect; force can exist only subsequent to union, and in consequence of union. The horrid prerogative of being able to make bad laws, supposes necessarily a state of ignorance; a state in which the vices of the laws are not illuminated by evidence; for it is impossible that a community should consent to uphold that which visibly hurts them. The power exists in this hateful situation, but the right as little there, as any where else.

The Economists come next to the important question, What is *the security for the right use of the legislative power?* On this subject, their anxiety to secure to their opinions the benefit of publicity, and the favour of those in whose hands the governing powers were actually deposited, led them to use the veil of expressions too general, and into some positive mistakes. "The security," they said, "for the right use of the legislative power, is the interest of that same power, which can, in the general order alone, find its own best possible state. The irresistible force which evidence acquires by publicity is also that security. This evidence exists in its greatest force in the body of the magistrates, who cannot, without ceasing to be ministers of justice, lend their ministry to the execution of laws evidently unjust; or forbear, without being criminal, their utmost endeavours to make the *evidence* of that injustice as clear as possible, both to the legislature and to the nation.

The grand question followed, *What are the hands in which the legislative power ought to be deposited?* Having demonstrated that the legislative and executive powers cannot by possibility exist in any but the same hands, and that they form together what they denominated the *tutelary authority*, they proceeded to inquire what was implied in the idea of authority. "Unite," said they, "upon one object a multitude of opinions and of wills; from that union will arise naturally and necessarily an union of physical forces for the accomplishment of those wills; and from the whole together will result an authority, or, in other words, *a right of commanding, founded upon a physical power of procuring obedience to what is thus commanded.* If these opinions and wills should disunite, and form, for example, two parties; the forces will for that reason be divided; there will be two forces, two authorities, and, by consequence, two societies. That two authorities cannot exist in the same society, they maintained by the following proof. Such authorities must be either equal or not equal. If equal, each of them taken separately is null. If unequal, the superior is the real and only authority. That, in the first case, each taken separately would be strictly and literally null, arose, they said, from the very nature of equality, which rendered it absolutely impossible that the one could do any thing without the other. Neither of them, therefore, could procure a single act of obedience, except by their union; but, at the very moment of their union, they cease to be two authorities, and form both together only one authority made out of the union of both. Unity is, then, a part of the very essence of authority; to divide it, is to reduce it to an incapacity of acting, that is, to extinguish it, for authority is not authority but in so far as it can act to procure the execution of its will."

From the necessary unity of the tutelary authority it followed, they said, by necessary consequence, that the organ of that authority must be one man. That the physical force which is one of its component parts, can be directed only by one will, is above the need of proof. But it is said that one will may be formed out of the union of several wills; and that the public force is not subject to the separate wills till the union takes place.

To this the Economists made answer, that, if the opposition of one will can suspend the effect of all the others, it reduces authority to inaction, and for that reason destroys it. The reason why physical force is necessary is, that you cannot count upon the union of all wills. If, to avoid this objection, you have recourse, they said, to plurality of suffrage, you build no longer on the basis of evidence. That which divides opinions is not yet evident. As nothing in government ought to be arbitrary, and every thing that is not arbitrary is founded on reasons, that is, *evidence;* there cannot be diversity of opinions on matters of government, except from the effect of ignorance, or of bad design on the part of the deliberants. But it cannot be determined by a few voices less or more, on which side the ground of evil lies: experience shows, that an accredited error may long unite partizans in much greater number than the truth by which it is opposed. The number of those who concur in an opinion cannot render that evident which is not evident; their opinion is only opinion still; which is, of course, subject to change, for nothing but evidence is unalterable. And with respect to bad design; as that results from particular interests, it can never be determined whether the number of those whom such interests command is the greatest or the least. On both accounts, then, plurality of suffrage is not security.

But the greatest evil, they said, of the mode of determining, by majority of votes, the question respecting the social order, was, that it set individual interest in opposition to public; in which case, the public interests are sure to be sacrificed. "How great soever the differences among men, they have within them, nevertheless, two grand moving powers common to all, and which are the source of all their actions; the appetite of pleasure, and the aversion to pain. To suppose that men can move in opposition to those powers, is to suppose that the cause can depend upon the effect. But the desire of enjoyment, and opinion by which it is modified, cannot act naturally and constantly in the direction of the public interest, when authority is divided among several persons who are liable to have interests opposite to one another. For it may be laid down as a truth, which will not admit of contestation, that the public interest cannot be considered as generally safe, when it is in opposition to the private interests of those who are entrusted with it. If one or more of the public administrators behold any great advantage to themselves in a sacrifice which has been made, or which may be made, of the public interest, we ask, said the Economists, What can prevent the sacrifice from being made? Not the two springs of action which nature has placed within us to be the cause of all we do; for they are, in this case, put in opposition to the public interest. Not any other authority in opposition to that of the public administrator; since, by the supposition, they themselves engross the whole of the governing power."

The remaining evil which the Economists ascribed to this expedient was, that it attached to the number of votes a despotical authority, which can safely and usefully belong to *evidence* alone. "Under this system, it is not evidence," they said, "which governs; it is opinion, or the will of a certain number of men actuated by the same opinion. The mischief apt to result cannot be estimated; it is without bounds. Suppose, in fact, that the vote of the majority is dictated by private interests, and that *evidence* is on the side of the minority; is it not monstrous that the former should command? and that the form of the government should lend to bad design a title to triumph over evidence itself? This excess of disorder is nevertheless inevitable, under so defective a plan of government; and the nation remains absolutely without protection against the scourges with which, under private interest, set in opposition to public, it may be lacerated; especially if these private interests are the interests of men who, by their riches or otherwise, are in possession of power.

"We forget not," they said, "that the mischievous tendency of private interest, would find a counterpoise in the *knowledge of the nation.* It is very true, that, in a nation really enlightened, a nation that had from *evidence* the knowledge of its own true interests, the body of rulers could not abuse their authority. But why? because the evidence of the abuse would, in that case, annihilate the authority. But the idea of a nation governed by plurality of suffrage, and by evidence at the same time, involves an absurdity. Again, a nation sufficiently instructed to know all the links in the chain of social good and evil, would never sanction a form of government which places the common interest in opposition to the private interests of those to whom it is entrusted. Besides, it would be ridiculous to suppose a nation sufficiently instructed to have the wills of all united under the evidence of what is best in the social order, and to suppose its rulers, at the very same time, so ignorant as to be divided on those subjects, and reduced for a ground of decision to plurality of suffrage.

"So long, on the other hand, as a nation is not thus instructed, the people, properly so called, sunk in ignorance and prejudices, see no farther than the nearest objects by which they are surrounded; each canton thinks the interest of the state is all summed up in the interest of that canton; each profession in the interest of that profession; the knowledge of relations and dependencies is absolutely wanting: such men cannot ascend from effects to causes, much less enumerate the links in the chain of causes and effects. It becomes, therefore, morally impossible for them to act by principle and by rule. Ever credulous and prone to prepossession, they must be gained in order to be persuaded; the same artifices must be practised upon them which are used to seduce them. The resolutions of men, the sport of momentary impressions, must have all the inconstancy of these impressions. Divided into rich and poor; the rich look upon the poor as made for them; and upon every power which they wish to possess, as naturally their due. The poor, justly discontented with the treatment they receive, and mistaking the cause, are tempted to envy the condition of the rich, and to regard as injustice the inequality of the partition which is made between them. It is evidently,

therefore, unsafe to choose the body of administration exclusively from either of these two classes. Nor would much be gained, if one half were chosen from the one and the other from the other. If the separate portions continued to be governed by the prejudices and views of the classes to which they belonged, they would do nothing but contend; and there is only one way in which they could receive a motive to cease; *if collusion would enable them to serve their own private interests by sacrificing the interests with which they were entrusted.*"

The Economists come, then, to their grand conclusion with respect to the artificial or physical security of the social order. To the question, what is the best form of government? They answered, The government of a single individual uniting in his own person the whole of the legislative and executive powers, in other words absolute. "All men," they said, "would confess that the best form of government was that which was so perfectly conformable to the natural and essential order of societies, that no abuse could result from it; that form, in short, which renders it impossible to make gain out of misrule; which subjects him who governs to the absolute necessity of having no greater interest than that of governing well." This advantage would be found, they affirmed, in the government of an hereditary sovereign, and it would be found in no other.

The reason was, that in no other could the interests of governor and governed be rendered absolutely the same. As the hereditary sovereign is the hereditary proprietor of the sovereignty, the interest of the sovereignty is his interest. The interest of the sovereignty means, the most perfect possible state of the governing authority; that is, the most perfect possible assurance of obedience to its command. But obedience to command can only arise out of the union of wills. And there can be no perfect assurance of the union of wills to obey, but from one cause; the evidence that what is commanded is for the benefit of those who are to obey. The interest of the hereditary sovereign, therefore, and the interest of the community, is one and the same.

With regard to the famous idea of the *balance* of a constitution;—that fancied arrangement of things in which the power and will of one part of the instruments of government finds a counterpoise in the power and will of another;—this pretended counterpoise the Economists treated as a perfect chimera, a mere imposition of the imagination, a sort of a day-dream.

The nation, they said, is either instructed or not instructed. Let us examine the supposition of the balance in both cases. If it is instructed, or, in other words, possesses the evidence of the causes of good and evil in society, there is no balance of forces; there is only one force, because force follows will, and here wills are united. They carry the developement of this idea to a great length, to which our limits will not permit us to follow them.

If the nation is not instructed, or, in other words, does not possess the evidence of the causes of good and evil in society, the establishment of counter-forces is impracticable. To ignorance there can be only one salutary counteracting force, and that is, evidence. The effect of ignorance in the sovereign is dreaded, and to remove the dread, another man's ignorance is provided. This is what people call making counter-forces: it must be confessed that they are not of the very best sort of materials. How could it ever be imagined that confidence for any thing stable, could be laid on any thing so unaccountable as the results of ignorance?

Let us adopt this chimera for a moment, and ask if it be possible to assure ourselves, that each force will be the same to-morrow which it appears to be to-day. It is evidently impossible; nay, what each appears to-day may be a *false* appearance; for resting only on opinion, detached from evidence, it rests on what can never be exactly known.

The idea of a balance is the idea of two powers, one tending by its own force in one direction, another urging it by an equal force in an opposite direction. The effect is rest. To balance the power of the sovereign, acting in one direction, you provide another power acting in an opposite direction. If the powers are equal, they destroy one another, and there is no action. If they are unequal, there are not two powers, but only one power; for the greater swallows up the less.

The theory of a constitutional balance is founded on a metaphor, a contrivance of language; and moral forces are supposed to be subject to the laws of material forces. Material forces acting on a body in different directions, make it assume a certain determinable duration between the two. But it has not been considered, that, in physics, the direction given does not depend upon the opinion of the things which act. In morals, on the other hand, the things which are depended upon for counteraction change their duration, according to their opinion. A theory which supposes that to be uniform and constant, which is known to be the reverse, is evidently absurd.

Suppose every thing which the theory needs to be supposed. Conceive an assembly, or assemblies, provided to counteract the sovereign, and so constituted, as to form the most perfect counteraction possible; that the sovereign can ordain nothing but with the consent of the assemblies, and the assemblies nothing but with the consent of the sovereign. In this case, it is not a government of one, but a government of many; each member of the assemblies shares in the sovereignty; they are so many partners, therefore, with a particular partner at their head. The question is, what are the interests of the partnership? Those of the nation or not? The interests of the partnership doubtless are, to make it as profitable to the members as possible; for it would be absurd to suppose them not governed by their private interests. Suppose, then, that there is originally a tendency to counteraction between the sovereign and the assemblies. It is very obvious, that they will put an end to this counteraction, as far as they discover that the suspension of it is conducive to their private interests. This is a law of nature, and may be taken for granted. As far, then, as the serving of the private interests of the members is

concerned, there is no balance of opposite forces; the forces combine instead of opposing, and so far the balance is lost. The loss of the balance to this extent may be a loss engrossing the whole of the protection to the common interest which it was expected to yield; or it may be a loss not extending so far. If it goes to the whole extent of that protection, there is to the purpose in question no balance at all. If it does not go to the whole extent, there will still be some balance, more or less. What then is the case? The case is, that the loss goes to the whole; and that the balance does not exist. The balance does not exist, as far as the private interests of those who share among them the governing powers are concerned. But it is only from the private interests of those who govern, that the nation has any thing to fear; it is only against these interests that the balance is provided. As far, however, as these private interests are concerned, the balance does not exist. As far, therefore, as the balance is even *supposed* to be of any service, the balance is excluded by the law of nature. It follows as a corollary, that in a country where the people depend upon what is called *a balance*, as the whole of their security for good government, they have no security at all.

Such is the analysis which the Economists present of the causes of good and evil in human society, and of that order of things, which best insures the presence of the one and the absence of the other. That part of their doctrine which alone is yet known to the mere English reader, their *political economy*, is introduced as only an auxiliary exposition. It is part of the developement by which they endeavoured to prove the identity which they supposed, between the interests of the sovereign and the interests of the people. But, as a very distinct account of this part of their system has been given by Dr Adam Smith, and has been repeated in a variety of publications; and as our object rather was the exhibition of those doctrines of the sect, which nobody has yet presented to our countrymen in their own language, we shall content ourselves with only marking the place which their political economy held in their general system.

As the society has public expences, it is necessary that it also have a public revenue. To reconcile the formation of a public revenue with the idea of social order, it ought to be formed, if possible, without infringing the property of individuals, for the sake of which the order of society itself is established. It ought, therefore, if possible, to be formed without diminishing the revenue of individuals. When the real origin of revenue, the source from which it all is drawn, is sufficiently understood, the mode of forming a revenue for the sovereign, without diminishing that of individuals, would be immediately apparent. *The source of all riches is the land; because the land alone, of all the sources of production, yields a produce greater than the cost of the production.* The surplus produce of the land, therefore, constitutes a fund, which is over and above the remuneration to the agents of production, and out of which the revenue of the sovereign may be taken, without diminishing the motive to production; that is, without retarding the natural progress of the state in wealth, population, and felicity.

To lay the foundation for this plan of a public revenue, it was necessary to prove that the land is the only source of production; and that manufactures and commerce, though they alter the form of things, never add any thing to the amount or value of production. In the developement of these views, one of the most remarkable results at which the Economists arrived, was the necessity of perfect freedom to all the proceedings which lead to production; as giving to produce that form which is most agreeable to those who are to make use of it. Till the time of the Economists, the necessity of holding those proceedings in chains, and binding them to the will of governments, was the universal doctrine of governments, and to a great degree of speculators themselves. The general principles of the Economists respecting the *freedom* of property necessary to constitute the foundation of social order, led them to infer the evil of those abridgments of freedom; but they examined the inference in detail, and showed that the meddling officiousness of governments to compel industry to one thing, and exclude it from another, not only failed to effect any good purposes, but of necessity created obstructions of the greatest magnitude to production in general; and tended powerfully to keep down the wealth, population, and prosperity of the state. The light which they diffused on this subject, and which soon produced a grand effect on the minds of men, was a good, the magnitude of which is beyond calculation.

Another of their conclusions is, that the revenue of the sovereign, taken, as they said it ought to be, wholly from the net produce of the land, ought to be a fixed and unalterable proportion of that produce. The reason appeared to them conclusive. If the proportion was variable, and depended upon the will of the owners of the land, they might be induced to break upon the public revenue, and deprive the state of those benefits which the public revenue is necessary to produce. If it depended upon the sovereign, the property of the land might be detached from that of its produce; no body would have a motive to become a proprietor in land; and all the advantages which depend on the existence of that property would be lost; the production of subsistence would fail; and the community could not exist.

This proportion being once fixed, there is no longer any contrariety between the interest of the sovereign and the interest of any portion of his people. And the proprietors of land are as completely and securely exempt from contributing to the expence of the state, as any other class of the community. The sovereign derives no part of his revenue from the subject; and this deplorable source of the conflict of interests is wholly cut off. The proportion being settled for ever between the sovereign and the land-owners, that alone is the property of the land-owner which is the proportion remaining to him. The rest is, with regard to him, as if it did not exist. The sovereign they denominated, therefore, *co-proprietor* of the land. And between him and the land-owner, commonly so called, a perfect community of interests is fixed. It is the interest of the sovereign that the produce of the land should in-

crease; because, with every increase in the produce of the land, his revenue increases. It is also the interest of the land-owner that the produce of the land should increase, because it is from the same cause that his revenue increases.

III. In the remarks which we have to offer on the doctrines of this sect, we must content ourselves with a few general strictures on one or two leading points.

The most important slips which the Economists made in tracing the laws of the social order, are found in their deductions respecting the *tutelary authority*. Many steps, nevertheless, in that doctrine they have established. That the legislative and executive power are essentially the same, and cannot be separated except in *appearance*, they seem to us to have placed beyond the reach of dispute. That no security for good government can be found in an organization of counter-forces, or a *balance* in the constitution, they have proved in a manner equally satisfactory. But we think they have not proved, that a security for good government can ever be found in the personal interests of a sovereign who unites in himself the whole of the legislative and executive power. And we think they have not proved that this security, if it cannot be found in the interests of such a sovereign, can be found in nothing else.

1. That the Economists do not reason correctly from their own principles, when they regard the interests of the sovereign as an adequate security for good government, may be made apparent, we should hope, by an argument of a very few steps.

In a perfect state of the social order, they say that the interest of the sovereign would be the same with that of the community; and the evidence of this identity would be so clear to the sovereign, that the effect of it would be irresistible on his mind. But in a perfect state of the social order, they say also, that the interest of *every* man would consist in the most exact conformity to all the rules of that order, and that the evidence of this truth would be so apparent as to be sure of its effect. In the only state, therefore, in which the interest of the individual entrusted with the tutelary authority could be relied on as a security, the tutelary authority itself would not be required; for in a state in which every man would, of his own accord, do what is best, an authority to compel him to do so would be worse than useless.

The moment when you suppose a tutelary authority to be necessary,—the moment at which you suppose there is any man in the community who can regard his private interest as consisting in any degree in what is hurtful to the community, how can you be sure that the depositary of the legislative and executive powers will not be that man? It can be easily shown that no man is acted upon by stronger forces to impel him in that direction.

In order to prove that the legislative power cannot be exercised by the community at large, the Economists declare expressly, "that if we study the nature of each man in particular, we shall find, in general, that he would, if possible, have nothing but rights on his own side, nothing but obligations on the side of other men. The legislative power can be exercised with safety only by those who possess in perfection the evidence of the justice and necessity of the original and pervading laws of social order. It cannot, therefore, be exercised in safety by a body of men, among whom unequal rights exist, and must exist; and who at the same time are all separately desirous that the inequality should be in their favour."

Admit this,—admit that all men in general desire to have nothing but rights on their own side, obligation on the side of other men; to have the inequality all in their own favour; to possess advantages, in short, over their fellows in the community; and it is surely absurd to talk of security in the interest of the sovereign.

It is a part of their doctrine, that he who is entrusted with the legislative power cannot be entrusted with the judicial power; because in that case the same party, both legislators and judges, would destroy law, by the exercise of arbitrary will. This is a direct admission, or rather an unlimited affirmation, that the interest of the sovereign is not a security such as good government requires. Again, it is said by the Economists, "that under a government conformable to the principles of order, the positive laws would be of a justice and necessity *publicly evident*; and that in order to apply these laws, the judges would unite two sorts of knowledge, both of its meaning and of its reason; and, secondly, a knowledge of the facts which constitute the case in which they are required to decide." No men, according to them, are more urgently called upon, none can be more reasonably expected to be in full possession of the evidence of that interest which every man has in the preservation of the social order. Yet so far are the Economists from saying that the interest of these men, and the evidence they could possess of that interest would be a sufficient security for the right administration of their trust; that they declare them liable to the greatest malversations, and that the ultimate security would lie in the sovereign, who would check them. It is surely matter of wonder, how the Economists could fail to perceive, that the very same motives which they rejected as security for the right use of authority in the judges, they trusted to as complete security in the sovereign; though likely to operate on the judges with greater force than upon him.

2. We think it may also be made apparent, that the Economists do not reason correctly from their own principles, when they conclude, that if security for good government cannot be found in the interests of one man entrusted with the whole of the legislative and executive powers, it can be found in nothing else.

They expressly state, that, "the first, the real depositary and general guardian of the laws is the nation itself, at the head of which is the sovereign. Accurately speaking, the deposit and guardianship of the laws *can* belong to those alone who are armed with the superiority of the physical force, to procure to that deposit its necessary superiority. This being evident, it is the nation as a body which naturally and necessarily is the depositary and guar-

dian of its own laws; because there is in the nation no power comparable to that which results from the combination of its powers." Again:—

In contending that the legislative and executive powers must always be exercised by the same hands, they affirm that those powers could only be exercised by those who had in their hands the superiority of the physical force. Observe, now, the legitimate conclusion:—

The people alone have the physical force necessary to constitute them guardians of the laws. The same force is necessary for the makers and the executors of the laws. No body, therefore, but the people, ever can, accurately speaking, have either the legislative or the executive powers.—In a state of ignorance they may be led by fraud to lend their powers to their own destruction. But it is a part, also, of the doctrine of the Economists, that in a state of knowledge, in which they may be easily placed, it is not possible they should make any but a good use of their power.

"A nation," they said, "governed according to the natural and essential order of society, has *necessarily* the perfect evidence and knowledge of it, and therefore sees with certainty that it enjoys its best possible situation. This perception of necessity, unites all the wills and all the forces in the nation for the support of that order; and, by consequence, for the creation and preservation of all the institutions which are best adapted to that support." The people, therefore, may be safely trusted.

In a nation governed badly, governed not according to "the natural and essential order," but according to what the Economists called the "*political* order;" "it is always," they said, "one part of the nation which governs the rest; the weaker which governs the stronger. In this case, too, the power of him who commands consists in nothing but the powers united of those who obey him. And this union of their forces supposes, of necessity, the union of their wills; which can be founded only upon the persuasion that this obedience procures them their best possible condition. The powers of the nation, in this vicious order, are less at the disposal of the sovereign, than at the disposal of those who hire to him their agency, and, by consequence, sell to him the means of procuring obedience from the nation; his situation is therefore at bottom a real dependence; his situation is precarious, uncertain, changeable; he is put in chains, which he dares not attempt to break." In every situation, therefore, it is the will of the people, either of the whole of the people united, or of a part of the people united against the rest, which is, in reality, both the legislative and the executive power. Estimate, therefore, as high as you please, exaggerate to any excess the inconvenience of being governed by the people, you have that inconvenience still; you are bound to it by the inexorable law of nature; it is not within the range of possibility that you should escape from it.

We have already seen, that the Economists declare, that "every man wishes to have all the rights on his own side, all the duties on the side of other men; that every man likes inequality, in short, when the inequality is in his own power." From this they infer, that the community cannot safely govern; but from this it may with much more justness be retorted upon them, that nothing else can safely govern. The interest of the community, say the Economists, is easily known; the evidence of it is within the reach of all descriptions of the people, and so cogent as to be irresistible. The union of wills, according to their doctrine, follows as a matter of course. Here, therefore, it should seem, we have a much better security, than can be found in the interest of any *individual*, sovereign or subordinate.

It is remarkable enough, that the Economists have wholly overlooked, in their criticism on the plans opposed to their own, *the representative system;* and yet it is pretty evident, that it is by means of the representative system, that the grand problem of government must finally be resolved. The speculations connected with this subject will, however, find a more fitting place under the article GOVERNMENT.

For the exposition of the original errors of this sect in *political economy*, it is unnecessary to do any thing more than refer to the immortal work of Dr Adam Smith. A few years ago, these errors, under something of a new form, were revived in this country, with a success which shows how much the *opinions* of that great proportion of the community, whose opinions are not formed upon *evidence*, are liable to change by every fluctuation of circumstances. From an opinion, which had governed this nation for ages, that to its commerce alone it owed its being the richest nation upon earth, our countrymen, under the momentary threat of circumstances, which created an unreasonable fear of being deprived of commerce, embraced, with an avidity hardly conceivable before experience, the doctrine of Mr Spence, that commerce was no source of riches at all. What the author of this article thought necessary to be said in opposition to these doctrines at the time, he presented in a tract, entitled, *Commerce Defended, in Answer to Mr Spence.** And an able exposure of the same errors was published on the same occasion by Major Torrens, in a pamphlet, which he entitled the *Economists Refuted.* (F. F.)

* The only part of Mr Mill's pamphlet to which it is of any use at present particularly to refer, is where he proves, that a balance necessarily exists between production and consumption; and that no amount of production can ever be without a market; a doctrine of cardinal importance, first illustrated by M. Say, in his very able work, entitled *Traité d'Economie Politique,* but of which the evidence will perhaps be found more clearly deduced in this pamphlet than in any other treatise yet published.

END OF VOLUME THIRD.

ERRATA.

Dissertation, p. 23, line 16, *for* potash *read* soda
——— p. 38, line 16, *after* raise them to *insert* a level with
——— p. 43, line 10, *after* 162° *insert* semicolon
——— p. 53, last line, *for* 1733 *read* 1773
Page 59, col. 2, lines 28 and 29, *for* province of Canterbury *read* province of York
—— 184, col. 1, line 1, *for* breadth *read* depth
—— 187, col. 2, line 58, *for* as before expressed *read* as before, expressed
—— 195, col. 2, line 27, *for* attempted *read* attempered
—— 196, col. 1, last line *delete* joint
—— 199, col. 2, line 48, *for* that *read* the
—— 200, col. 2, line penult, *delete* diamb
—— 241, col. 1, line 34, *for* fit. The pot *read* fit the pot
—— 242, col. 1, line 16, *for* bolts *a*. At the upper part *read* bolts *a* at the upper part
———— 47, *for* so *read* to
—— 244, col. 2, line 37, *for* K *read* *k*
———— 40, *for* and *read* to
—— 245, col. 2, line 59, *for* spring *read* ring
—— 246, col. 2, line 43, *for* *k* *read* K
———— 53, *for* slider *read* socket
———— 62, *for* close *read* open
—— 247, col. 1, line 32, *after* down *delete* semicolon
—— 253, col. 1, line 43, *for* successively *read* successfully
—— 256, col. 1, line 37, *for* barometer *read* thermometer
—— 258, col. 2, line 60, *for* of either great or small *read* of great
—— 397, col. 2, line 49, *for* No. 110 *read* No. 100
—— 400, col. 1, line 25, *for* that that *read* than that
—— 406, col. 1, lines 27 and 28, *delete* chiefly Methodists

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